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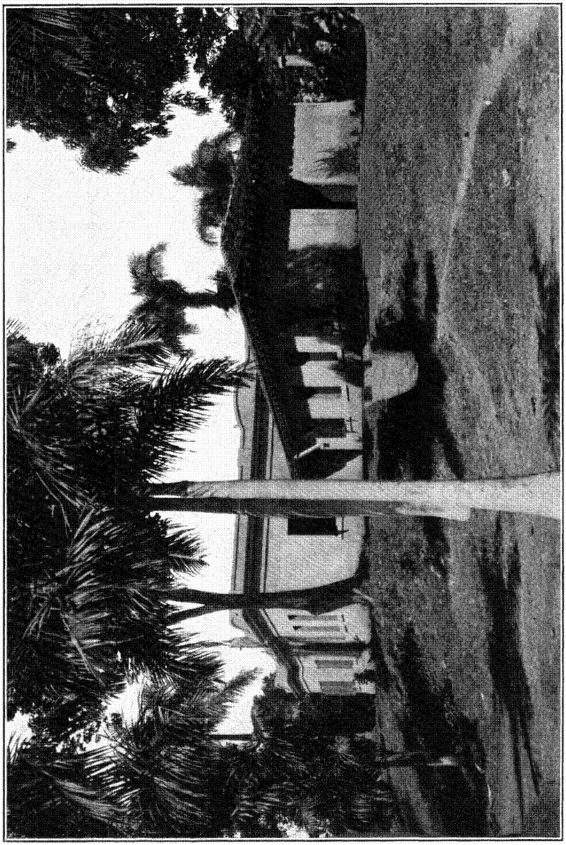
PORTO RICO AGRICULTURAL EXPERIMENT STATION

D. W. MAY, Special Agent in Charge.

ANNUAL REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION FOR 1910.

UNDER THE SUPERVISION OF
OFFICE OF EXPERIMENT STATIONS,
U. S. DEPARTMENT OF AGRICULTURE.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1911.



NEW EXPERIMENT STATION BUILDING.

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PORTO RICO AGRICULTURAL EXPERIMENT STATION.

[Under the supervision of A. C. TRUE, Director of the Office of Experiment Stations, United States Department of Agriculture.]

WALTER H. EVANS, *Chief of Division of Insular Stations, Office of Experiment Stations.*

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LETTER OF TRANSMITTAL.

PORTO RICO AGRICULTURAL EXPERIMENT STATION,
Mayaguez, P. R., December 22, 1910.

SIR: I have the honor to transmit herewith and to recommend for publication the Annual Report of the Porto Rico Agricultural Experiment Station for the fiscal year 1910.

Respectfully,
D. W. MAY,
Special Agent in Charge.

DR. A. C. TRUE,
Director, Office of Experiment Stations,
United States Department of Agriculture,
Washington, D. C.

Publication recommended.
A. C. TRUE, *Director.*

Publication authorized.
JAMES WILSON,
Secretary of Agriculture.

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ANNUAL REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION FOR 1910

SUMMARY OF INVESTIGATIONS.

By D. W. May, *Special Agent in Charge.*

INTRODUCTION.

Whatever may be the results in the various efforts made by the United States Government in improving the condition of alien peoples there can be no doubt as to the material improvement in the living conditions of the people of Porto Rico. In a few years a prosperity has been reached hitherto unknown in the history of Porto Rico. This has been brought about on an impoverished soil and in a country where the natural resources have been practically exhausted.

The prosperity of Porto Rico depends essentially on her agricultural products. Gold mining is exhausted and manufacturing is confined to a very few lines and a small output. While the island is thickly populated, more so than any of the States except two, the people are scattered through the country rather than in towns. They live from the soil.

The exports and imports representing the trade of the island in 1901 was $17,502,103. In 1910 it had increased to $68,595,074. This trade is due to the greatly increased agricultural production of the island, which has not only given impetus to all the industries, but has greatly improved the living conditions of our people.

The resources of Porto Rico reside in her soil and labor. That these languished in years gone by was not due to the sterility of the one or the unwillingness of the other, but to a lack of enterprise. The latter has been inspired by a conservative government, the introduction of capital, and a broadening market.

SUGAR.

Of the $37,960,219 of exports during the fiscal year 1910, sugar and molasses totaled $24,145,046. Since the earliest times Porto Rico has been noted for the quality of her sugar cane. The strip of level land bordering her seacoasts has been mainly devoted to this crop. Since the American occupation this industry has had a phenomenal growth, brought about by favorable trade relations with the United States, the installation of modern equipment in both the cultivation and the grinding of the cane, and in modern methods of culture. Although the cane acreage has been increased, the greater gain has resulted from a better preparation and cultivation of the soil and the application of fertilizers. The greatest increase in the future production of sugar on the island will be brought about by more intensive cultivation, augmented to some extent by a larger acreage planted to cane.

Owing to the profit of cane growing under present conditions in Porto Rico the planter endeavors to continue this crop on the land without rotation. This is contrary to the best practice in agriculture, and, to succeed, the grower must apply an unusual skill or disaster will overtake him. The first endeavor among progressive planters has been the changing of varieties, especially the introduction of the new productions obtained from the seed. The experiment station has for several years been engaged in breeding new canes and importing those of other stations in the West and East Indies. The aim in this work is to secure a cane of larger tonnage, greater sweetness, and resistance to disease.

During the year a bulletin embodying the results of experimental work along several lines was issued in both English and Spanish. The work with cane consists in breeding new varieties, the study of diseases, and especially investigations in cane soils. The latter is directed to the amelioration of lands that have been planted to cane for many years and which as a result have become "tired" or "sick." This applies especially to the study of the biological conditions. The means employed in improving such soils is disinfecting by the use of various chemicals.

The sugar planters, realizing the importance of scientific research in the improvement of their industry, have organized their own station for the study of the questions directly affecting sugar production. A tract of land has been purchased and a staff selected. The various phases and factors influencing sugar production will be studied. This station, working in harmony with the Federal station, will greatly profit the industry in Porto Rico. It will also relieve to some extent the latter station, which is endeavoring to cover many lines of work in the large and important field of tropical agriculture.

COFFEE.

There was sold from the island during the year coffee to the value of $5,669,602. Of this amount only $21,876 went to the United States. Naturally a product goes to its best market, and the sales in this instance indicate that our coffee is better appreciated in foreign than in the home markets. The cause is not far to seek. Coffee, like other beverages, is rated upon its flavor or aroma. The preference of a people in this regard is largely a matter of training or habit. The trade on an article of uniform quality, as sugar, will change quickly with trade relations, but a variable product, as coffee, changes its lines of trade very slowly.

In most of the countries of Europe and former colonies of Spain, as Cuba, the peculiar flavor of Porto Rican coffee is relished. In the States a highly flavored coffee, as certain classes of Java, has the preference. The Porto Rican coffee is the highest type of after-dinner black coffee. The home market prefers another type. In the States Porto Rican coffee is not properly made. Here the bean is roasted black, in the States it is browned. The method followed here is the proper one for a black after-dinner coffee; that in the States is correct for a highly flavored coffee where it is desired to preserve the peculiar aroma contained in the essential oil.

It is hard to change the taste of a people, and it is often more profitable to cater to it than to attempt to change it. As long as the present type of coffee is grown in Porto Rico it must be marketed abroad. If the market in the States promises better returns, then the type of coffee that will meet the demands there and command the highest prices must be grown.

Our experiments indicate the possibility of growing Java and other coffees and maintaining their peculiar flavor. It will take more time, however, to determine how these coffees will be received in the States markets. It is necessarily slow to change a product grown on trees owing to the time in which they reach a stage of profitable production. Seeds of introduced varieties of coffee have been distributed, and a number of planters are making practical comparisons with native coffee.

There is a marked improvement in the condition of many plantations, and with the higher prices now ruling proprietors are giving better cultivation to their trees in both cleaning and pruning and in some instances in fertilization.

There is also a growing tendency to a greater diversification of agricultural products. Planters are finding that other things than coffee pay on the mountains of Porto Rico. Where accessible to roads budded oranges and grapefruit are being planted and in many instances wild trees have been budded over. Other products, as bananas and charcoal, are being marketed in the near-by towns. This is a move in the right direction, for in a country of small proprietors such as this the one-crop idea will not succeed.

TOBACCO.

Tobacco is third in value of the crops produced on the island. With the added value through manufacture, the exports aggregated $5,763,214. The most notable feature of this production is the increase of local manufactures. This is about the only line in which manufacturers have taken advantage of the large supply of labor. The industry is likely to show a great increase, as the supply of labor is large and, moreover, is of a class singularly adept in making cigars and cigarettes. There was imported during the year for the purpose of manufacture tobacco leaf to the value of $370,645. There was exported, however, leaf tobacco to the value of $1,140,904. Cigar tobaccos solely are grown in Porto Rico. Cigar wrappers are grown under cheesecloth and this part of the industry is carried on by companies with considerable capital. The large part of the filler tobaccos, which are grown in the open, is produced by small planters. The tobacco companies largely manufacture their product; the small grower sells for what he can get in an open and rather restricted market. Having no organization, the prices he receives are low. There has been a trend toward lower prices for several years, and persons who have come to Porto Rico for the purpose of growing tobacco to sell in the leaf have lost considerable money. With but a few buyers on one side and an unorganized lot of producers on the other, and with new and unknown pests to contend with, the tobacco grower has had a hard time.

Greater skill is required to grow tobacco in the Tropics than in the north. The soil itself presents more problems and the seasons are more variable. The insect pests are more numerous and formidable. Losses in Porto Rico have been especially heavy in the seed bed. Some method must be devised for disinfecting the seed bed before planting. Burning the ground before sowing the seed, as practiced in the States, would doubtless prove of value. In some cases studied by the station losses in the seed bed have been occasioned by nematodes.

FRUIT.

The agricultural pursuit capable of the greatest expansion in Porto Rico is fruit growing. This is due to the great area of land capable of producing some class of fruit and especially to the enormous production of tree fruits on a given area. Most of the planters who have come to the island since the American occupation have engaged in fruit growing. This industry has shown the greatest growth. From shipments of wild oranges five years ago to the value of $125,311 there has been an increase to last year of fruits valued at $1,416,947. Of this amount oranges totaled $582,716, pineapples $555,044, grapefruit $162,749, and canned pineapples $106,587. Some other fruits are coming on the market, as the mango, and give promise of making a commercial success.

The progress in fruit growing has been made under most trying circumstances. Soils employed for this purpose have been depleted largely of their fertility. In most localities they are wind swept. Again, fruit growing here is a pioneer industry and methods must be worked out by experience, which is always expensive. Even conditions that seemed similar to those obtaining in older fruit-growing countries were found to vary when practically tested in Porto Rico.

Failure has resulted from lack of experience with some planters and from lack of application with others. Again, some companies with glittering prospectuses have not made good and as a result investors have lost large sums of money in Porto Rico, thus causing much injury to the country and the fruit industry.

To succeed in fruit growing in Porto Rico a capable, honest, and industrious manager is very essential. He must reside on the land and give it his constant and unremitting attention, for disaster lurks in every season. Planting the tree and waiting for results will fail every time.

COCONUTS.

Among the miscellaneous products the coconut brings the greatest revenue into the island. It is grown in a comparatively small area, the fringe of sandy beach bordering the coast line. The nuts are of superior quality, easily grown, and bear abundantly. It is almost impossible to buy a bearing grove. The area planted shows some increase, but the soils best adapted to the crop are pretty well taken up. The yield could doubtless be much increased by more fertilization and better cultivation. In most cases the groves are unplanted to other crops, though it is a good practice to grow small cultivated crops, especially beans, among the trees. The nuts are shipped whole to New York and are used largely by the makers of desiccated coconut for use in pastry, etc. About seven years are required for the trees to come into profitable bearing, but after that the crop is sure and the cost of maintenance low. The coconut-bud rot is not known to occur here and such pests as are present are easily controlled.

LIVE STOCK.

The trade in live stock in the island has undergone a complete change in a few years. From exports of three to four hundred thousand dollars of a few years ago it has dwindled to nothing; on the contrary, animals both alive and as dressed meat are now a large item of imports.

This change has been brought about by the greatly increased needs for work animals and also the greater consumption of meats due to an increased prosperity. Animals of all classes, especially horses, have increased greatly in price. Dressed meats also have become a luxury and beyond the reach of most of the laboring classes. Chilled meat is shipped in from the States, and dried or jerked beef from Argentina.

The experiment station has devoted considerable effort to importing pure-blooded animals, and studies have been made in the practical methods of handling and feeding domestic live stock in the Tropics. A study of the influence of certain mineral nutrients on animal growth, which has developed some interesting results, is in preparation for printing.

FIBERS.

Sea-island cotton is the principal fiber crop in Porto Rico, but its culture has made little progress, and it can hardly be called an industry. It is grown by small planters, who do not give the crop the attention it deserves. They neither produce, as a rule, the good quality that should be expected nor understand handling or marketing their product. It is usually bartered to the local merchant, who does not offer a price based on the quality, a practice which would lead to the best efforts on the part of the grower.

There is no doubt of the quality of Sea-island cotton on the best lands. Samples submitted to experts for grading were rated as worth 37 to 39 cents per pound.

In cooperation with the insular government a commercial planting of Sea-island cotton has been made and a roller gin purchased. Besides teaching better methods in growing, it is hoped to develop better means of preparing and marketing cotton in Porto Rico.

Of the introduced fibers sisal is promising as a money crop. The Panama-hat palm is now grown in several sections, and the weavers are begining to use the fiber. Ramie grows well at the station and might be taken up could suitable machinery be devised for its economical extraction.

COOPERATION.

The station has a number of cooperative projects under way, as follows: With the insular government in growing fiber crops; with the United States Department of Agriculture in the introduction of economic seeds and plants; with a number of planters in fertilizer trials on various soil types, in soil disinfection, in testing new seedling canes, in animal cross breeding, and in the dissemination of parasites of insects.

RUBBER.

Many inquiries are received by the station as to the suitability of Porto Rico as a rubber-producing country. Our experiments have not yet gone far enough to draw definite conclusions, but it does not appear that the island will enter to any extent into this industry.

Although some varieties of rubber-producing trees have grown well at the station, their extended planting can not be advised. Doubtless on many farms there are areas where trials might be made to employ profitably what is otherwise waste land. As a commercial proposition rubber can not at present be recommended, for the following reasons: The yields of rubber per tree are low, lower in fact than most of the literature on rubber would lead one to believe; lands are too high in value to undertake rubber growing; Porto Rico is close to and has free entrance to the best market in the world, and the most profitable products to grow are either those that are favored by a protective duty or that are of such a perishable nature as to prohibit competition from more distant lands. Again, the rubber industry is highly speculative. When the raw product will double in price in a year and fall again to less than half, it is very evident that its profitable production is highly unstable. Moreover, cultivated rubber must compete with wild rubber, the extent and cost of which is very difficult to estimate.

PROPAGANDA.

The success of the work of an experiment station must necessarily depend in large measure upon the adoption of the results by the people for whose benefit the experiments are made. Although more interest is manifested each year by the people of Porto Rico in improved agriculture, yet the station feels handicapped by not being able to make a more active campaign in extension work. This lack the agricultural college will fill in time. Also it seems likely that an insular bureau of agriculture will be established. Such is highly desirable and the time is ripe. While the island has been much improved in the way of roads and buildings, made possible by increased revenues, but a small portion of the revenue has been directly applied to improve the industry which makes them possible.

The correspondence of the station has grown enormously and much information has been disseminated by letter as well as by published bulletins and reports.

Considerable traveling has been done by the several members of the station staff throughout the various agricultural sections of the island. Means of transportation are improving each year, but much is yet to be desired. While the area of Porto Rico is limited, being about 100 miles long by 40 miles wide, yet owing to the broken nature of the surface travel is tedious and expensive.

During the summer a six weeks' school of instruction held at the station was attended by over 100 persons. This session was of an entirely practical nature, and was held for the object of stimulating an interest in improved agriculture such as would lead to its more extended study and application. Several conferences with displays of agricultural products and methods were held during the year. These conferences were largely attended and much enthusiasm was shown.

STATION WORK.

The work of the station is limited only by its income. The present needs are great because of the wide and unexplored field of tropical agriculture and the limited number of persons engaged in this branch of agricultural science.

Continued efforts have been made to direct the work into more definite lines, especially those relating to tropical conditions. Especial attention is given to soils. With a climate of continuous summer and a bountiful rainfall the production of crops in the Tropics would seem to require only a reasonable tillage, but such does not always produce the expected results. The solution of the question resides in the soil. In the Temperate Zone after the freezing and thawing of winter, soils seem in better condition to produce a crop. In the Tropics, where such conditions do not obtain, soils seem less responsive at a definite season of the year. It seems, however, that after lying fallow, or following a drought when the soil has become thoroughly dried, the growth of plants is usually much more active. Soils burned over become much more responsive and plants grown in such areas soon outstrip others where no burning has taken place. Again, it is found that certain disinfectants render tropical soils more productive, although they add nothing directly in the way of fertility. Tropical soils are filled with many bacteria, some of which, notably certain anaerobic forms, are detrimental to the best growth of plants.

The work in medical science in the last decade has rendered the Tropics habitable to northern races, and has undoubtedly paved the way for the migration into this region which has already set in. Agricultural science is also destined to render this region, naturally favorable in many ways to man's comfort and happiness, the most prosperous section of the world.

REPORT OF THE PHYSIOLOGIST.

By Oscar Loew.

ARE PROTOZOA CONCERNED IN SOIL SICKNESS?

The existence and general occurrence of protozoa in soils is but a recent observation. When soils are examined under the microscope, it is a difficult matter to discover them, but as soon as a suitable nutrient solution is added to soil, the protozoa will multiply by feeding upon the soil microbes and can then be easily seen in every drop of the liquid. Probably the infusoria are periodically encysted in soils, especially in dry seasons, and develop afresh as soon as water and organic matter bring on an increase of microbes.[1]

When cultures are made in the usual way for Azotobacter in soils, a most favorable development of protozoa takes place also, especially of infurosia, and to a less extent of amœbæ and flagellatæ, all feeding upon the cells of Azotobacter. Azotobacter occurs not only in the surface soils of arable land but also in sand dunes, as was found in examining one of a North Sea island (Borkum); there was also present at least one kind of infusoria. It was not suspected that such a loose sandy soil, not organically manured and almost free from calcium carbonate, would contain Azotobacter.[2] This organism, often accompanied by the butyric bacillus, was also observed upon leaves in Porto Rico, while in Temperate Zones Azotobacter was not found upon leaves.

For sake of convenience the test for both Azotobacter and protozoa may be mentioned here. A conical flask of about 100 cubic centimeters capacity, provided with a cotton plug and containing 15 to 20 cubic centimeters glucose nutrient solution, free from nitrogen compounds, and 5 grams calcium carbonate, is sterilized and then about 10 grams of the carefully collected soil is added. After shaking well the mixture is left at 16° to 25° C., protected against the direct rays of the sun for one to three weeks. The glucose nutrient solution mentioned contains 1 per cent glucose, 0.2 per cent monopotassium phosphate, and 0.02 per cent magnesium sulphate. A film of Azotobacter cells, gradually turning brownish, will appear, accompanied by various other microbes and by protozoa.

---

[1] It was observed more than 30 years ago by Nageli that the microbes are the main food of infusoria. He attributed to this circumstance the limitation of bacterial growth in polluted waters. The writer has observed vinegar eels feeding upon bacteria and certain aphids subsisting on the spores of mold fungi.

[2] The dune from which the sample of soil was taken at a depth of 5 to 6 centimeters was neither close to the seashore nor to cultivated land. It was moderately covered by a growth of *Rubus fruticosus* and Rhododendron. The film of Azotobacter developing after three weeks standing of the test flasks, was of faint brownish color; the cells—mostly "diplococci"—appeared to be smaller than those of the widespread kind, *Azotobacter chroococcum*.

It may sometimes happen that soil of a certain depth in which Azotobacter is absent is to be tested for protozoa. In such a case an inoculation of the soil with a pure culture of Azotobacter would be the simplest way to provide food for the development of protozoa in the test flask.

Now, observing the eagerness of the protozoa in devouring the cells of Azotobacter, the inference might easily be reached that the protozoa can cause injury to soils by decimating or reducing the number of useful microbes, which enrich the soil with nitrogen compounds or cause the formation of humus, or produce ammonia from combined nitrogen compounds. A. D. Hall,[1] of the Rothamsted Experiment Station, has recently suggested the theory that protozoa in the soil act injuriously by preying upon bacteria that transform organic nitrogen compounds into ammonia, thereby rendering them available. An increase of ammonia had been observed by Russell and Hutchinson in soils that had been treated with disinfectants. But in the paper at hand it was not stated whether the increase of ammonia was observed immediately after treatment or after several days, when the number of microbes had been again on the increase. Nor was it stated whether all protozoa were really killed by the disinfectant; encysted infusoria may be resistant. If an increase of ammonia was observed immediately after disinfection another explanation than that of Hall may be possible.[2] Heinze as well as Pickering[3] had already observed an increase of soluble organic matter in the soil after treatment with antiseptics.

How far the protozoa are concerned in the "tired" condition of soils can be properly estimated only when their relative number in different soil strata to a depth of 1 meter have been determined and when it has been definitely determined to what degree the multiplication of microbes is kept down by the voracity of these organisms.

Soils with restricted aeration, as clay soils and stiff loam soils, will probably show protozoa only on and near the surface, since the bacteria in the deeper strata will soon render the limited store of air unfit for the respiration of protozoa. Clay soils especially often show a sick condition of a peculiar order. Neither parasitic microbes, fungi, or organisms such as nematodes can be found in many such cases. This may be attributed to two causes—either the total number of microbes have so far increased as to cause suffocation or the number of certain injurious microbes of fermentation and reduction have reached an unhealthy increase. The observations of the writer convinced him that both these causes can occur.

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[1] Address to the Agricultural Subsection of the British Association for the Advancement of Science, Sheffield, 1910. Published in Science, 32 (1910), No. 820, p. 363. The writer had published in Science, 31 (1910), No. 808, p. 988, a note on soil bacteria in the Tropics, stating among other things that "Infusoria, flagellatæ, and amœbæ devour great numbers of microbes."

[2] Hall's discussion was based upon investigations by Russell and Hutchinson, reported in full in Jour. Agr. Sci., 3 (1909), No. 2, p. 111 (E. S. R., 22, p. 121).

[3] Cf. Porto Rico Sta. Circ. 11, pp. 6, 7.

In loose soils no doubt injurious organisms, which need not be of the parasitic class, can also cause a "tired" condition by eating away the fine roots and root hairs. There might even exist injurious nematodes of a nonparasitic nature. A careful examination on these points must settle the question.

The theory of Hall may no doubt be correct in special cases; it is only the generalization of it which does not seem admissible. The numerous protozoa which are observed when soils are kept for a few days in a nutrient solution are the result of much more rapid multiplication than takes place in the soil under usual conditions, and hence their relative number might be overrated.

The beneficial action of certain kinds of microbes is doubtless an important factor, but in view of these useful effects[1] it is often forgotten to consider the opposite side. There doubtless also exist various harmful organisms among the soil bacteria, nonparasitic and parasitic.

A COMPARISON OF SOIL DISINFECTANTS.

Since the question of the cheapest and most effective way of disinfecting a sick soil is of practical importance, the following experiment was carried out in soil where lilies had suffered for a series of years, as shown by the decreased flower production, yellowed leaves, and degenerate and more or less rotten bulbs. True parasites were absent, but aphids were noticed in the adhering earth; their number, however, was too small to be considered seriously. Desulphurization microbes and butyric fermentation bacilli were adhering to the roots and to rotten parts of the bulbs to a great extent. Two grams adhering soil[2] produced in five days at 30° to 34° C. 12.5 cubic centimeters gas (carbonic acid and hydrogen) and 0.038 gram butyric acid (with some acetic acid). A piece of root of 0.7 gram, fresh weight, yielded, with 100 cubic centimeters of nitrogen, free glucose-culture solution in absence of air at 30° to 34° C. after five days an intense butyric fermentation, and titration showed a content of 0.246 gram butyric acid.

---

[1] That under certain conditions bacteria are entirely superfluous in the soil is not only shown by the success of sand cultures, but also by the full plant development on soils almost devoid of organic matter and free of microbes, as has been observed at this station with a soil of 6 meters depth.

[2] The soil was a coarse, sandy soil, poor in clay and humus. When heated in a test tube, vapors of a strongly alkaline reaction and empyreumatic odor were developed.

The lily beds were divided into five plats, each measuring 1.5 meters in length and 1 meter in width.

A received 100 grams chlorid of lime, dissolved in 5 liters of water, administered partly in holes and partly on the surface.

B received 110 grams potassium permanganate, dissolved in 10 liters in the same way.

C received 30 grams tricresol in 5 liters of water.

D received 250 cubic centimeters bisulphid of carbon in 5 holes, which were closed at once and then water poured on top.

Six weeks later, April 8, each plat received six, about equally large, potted cultures of three to four healthy bulbs of *Lilium candidum*, which cultures had leaves from 21 to 24 centimeters in length and were planted with the adhering earth. Gradually bud-bearing stems developed from some of the cultures, and on June 6 the conditions were as follows:

Effect of soil treatment on flower-stalk development.

Plats.	Number of bud-bearing stems.	Number of flower buds.	Average height of stems.
			Cm.
Check	4	18	69.0
Chlorid of lime	8	55	90.0
Potassium permanganate	6	31	65.3
Tricresol	7	39	62.5
Bisulphid of carbon	5	35	67.1

The plat with chlorid of lime produced the most flowers.

On viewing the plants in autumn the development of new leaves from the bulbs on plats treated with the tricresol and bisulphid was noticed to be far in excess of those on the other plats. When harvested, October 22, it was noticed that the bulbs in the control plat were of insufficient cohesion, the outer shells often in brown and rotten condition and breaking off easily; next in quality were those of the tricresol bed. Most of the bulbs in the other plats were of firm texture and perfectly healthy, and in the bisulphid of carbon plat especially they had grown to a considerable size. In all plats the young bulbs were few in number; only 2 were found in the bisulphid and tricresol plats, 4 with permanganate, 7 with chlorid of lime, and, strangely enough, 10 on the check plat. It appeared that the unfavorable condition of the old bulbs on this plat had promoted new formations. The further determinations are seen from the following table:

Effect of soil treatment on growth of lilies.

Plats.	Average weight of one bulb.	Fresh weight of leaves of total crop.
	Grams.	*Per cent.*
Check	42.8	13.8
Chlorid of lime	47.0	12.8
Permanganate	51.1	10.6
Tricresol	57.9	18.2
Bisulphid of carbon	53.9	20.9

It will be noticed that the chlorid of lime plat which produced most flowers was behind in the growth of old bulbs, a correlation due to a certain exhaustion. The comparatively greater production of leaves on the bisulphid plat indicates that there had been an increase of available soil nitrogen.

Since flowers and seed formation were most increased by chlorid of lime, this must be considered as the most favorable and cheapest disinfectant in this case. Chlorid of lime has apparently thus far never been used in soil disinfection, and this case as well as some other experiments of this station are the first in this line.

REPORT OF THE CHEMIST.

By P. L. Gile.

INTRODUCTION.

The work carried on since the last report has been of the same character as that of previous years. Miscellaneous routine analyses have been performed, an investigation on pineapple soils commenced in 1908 has been completed, and satisfactory progress has been made in several other investigations on soils and plant nutrition.

Laboratory facilities have been improved by the addition of a room and by the purchase of a new balance, extraction apparatus, and a vacuum drying oven.

SUMMARY OF THE WORK.

The analytical work has consisted of the analysis of 290 samples of sugar canes, molasses, waters, limestones, soils, plant ashes, stable manures, bat guanos, and commercial fertilizers. Also, many qualitative examinations have been made of ores, fertilizing materials, and soils sent to the laboratory for information.

The investigations now in progress are on soil disinfection; the availability of the nitrogen and phosphoric acid in bat guanos; the effect of strongly calcareous soils on the growth and composition of various plants; the cause and correction of lime chlorosis; the effect of various ratios of calcium and magnesium chlorid on rice.

PINEAPPLE SOILS.

This investigation, begun in 1908, was for the purpose of discovering the cause of the failure of the pineapple crop on certain soils where the plants presented a peculiar bleached or chlorotic appearance. Since the mention of this trouble in the last report many new cases have been found in different parts of the island, and it is apparent that the soil condition causing it is more widespread than was at first suspected. The detailed results of the investigation are being prepared for publication, but brief mention is here made of some of the more important facts.

The bleaching or chlorosis of the plants is a result of malnutrition caused by the excessive amount of calcium carbonate contained in the soils. It appears that a content of more than 2 per cent of calcium carbonate renders ordinary soils unsuited for pineapples. Soils with an exceptionally high content of organic matter, such as occur in the Florida Keys, are suited for pineapples in spite of a high content of calcium carbonate. No soil of this character, however, to our knowledge, exists in Porto Rico. Soils containing much calcium carbonate are alkaline in reaction, but it is not the mere alkalinity that induces the chlorosis.

Treatment of chlorotic plants with ferrous sulphate has resulted in restoring the normal green to the leaves and in stimulating the growth. It is doubtful if this treatment, however, would make plantings on such soils commercially profitable. Treatment with fertilizers is not effective in curing the chlorosis.

These soils can be profitably planted with many other crops; lime-loving plants such as tobacco, coconuts, and gandules do well.

Some facts and analytical results which are not connected with the above lines of investigation and will not be published elsewhere are mentioned here.

A CALCAREOUS HARDPAN.

A peculiar soil condition occurring in a citrus grove 3 miles west of Bayamon, P. R., came to our notice during the past year. This plantation consists of about 200 acres of 10-year-old grapefruit and orange trees. Since the establishment of the plantation many trees have died in certain of the groves, apparently from unfavorable soil conditions.

Just previous to setting out the plantation the land was covered with a heavy forest growth of large trees. The surface soil is a rather fine sand and in most parts is rich enough in humus and organic matter to have a loamy character. The chemical composition of the surface soil varies considerably in respect to the content of lime, some areas containing less than 1 per cent and others containing 10 to 15 per cent. Sample No. 221 is the surface soil from one of the groves and No. 220 is the subsoil.

Analyses of soils from citrus grove.

Constituents.	No. 221.	No. 220.
	Per cent.	*Per cent.*
Insoluble residue	70.09	61.59
Potash (K_2O)	.18	.09
Lime (CaO)	5.40	13.93
Magnesia (MgO)	.17	.80
Ferric oxid and alumina (Fe_2O_3 and Al_2O_3)	12.45	9.56
Phosphorus pentoxid (P_2O_5)	.13	.09
Loss on ignition	10.94	13.11
Total	99.36	99.17
Nitrogen (N)	.31	.03
Moisture	2.21	.65
Reaction to litmus	Alkaline.	Alkaline.

The alkaline reaction is due to calcium carbonate, as no water-soluble alkalis were found present.

At a depth which varies from 2 to 8 feet a stratum of impervious red clay or hardpan is encountered. In spots where many trees have succumbed the sand lying some distance above the clay hardpan and below the surface soil is of a cementlike character. Dead trees show the roots embedded in this mass as though set in cement.

In one grove of some 40 acres on this plantation about 40 per cent of the trees have succumbed at various times. In this grove the layer of rocklike sand lies from 6 to 18 inches below the surface and is about 18 inches thick. Between the cemented sand and the clay hardpan loose sandy soil occurs. On crumbling this rocklike material it is seen to be composed of essentially the same soil particles as occur in the loose soil above and below it. From the proximity of the land to the sea it was thought probable that alkaline salts might play some part in cementing the soil particles together. Accordingly the water of a well located in the field was analyzed as well as a water solution of the substance. The water solution showed that no appreciable quantities of any soluble salt were contained in the material. The analysis of the well water was also low in alkaline salts.

On treating a sample of the cemented soil with dilute hydrochloric acid and observing the action under the microscope it was apparent that the soil particles were bound together by calcium carbonate. Particles of quartz and other minerals were seen to be connected and, in some cases, coated by a thin layer of calcium carbonate. This sandy cement may then be termed a calcareous hardpan.

From the observations of the manager this calcareous hardpan apparently forms rather quickly in spots. That it was not always present like the clay hardpan is evidenced from the occurrence of loose sandy soil above and below. The occurrence is probably to be explained somewhat as follows:

The underground soil water which, in certain times, is to be found on the layer of clay hardpan, becomes charged with carbon dioxid and so dissolves the calcium carbonate contained in the soil. As the soil water rises by capillarity it carries calcium carbonate held in solution by the carbon dioxid. As this solution nears the surface, carbon dioxid escaping and water evaporating, calcium carbonate is deposited between the soil particles, cementing them together.

Certain observations lent credence to this view. Several pieces of the hardpan were found in which there were small cracks or fissures. These cracks were lined with a continuous white layer of calcium carbonate. Under soil conditions, such as the presence of much humus, which would keep the soil loose and diminish the rise of underground water, the hardpan did not approach so near the surface.

To combat the formation of this calcareous hardpan probably the most effective measure would be good drainage on a level with the stratum of impervious clay. The addition of organic matter, and any treatment which will tend to check the rise of underground water or prevent the accumulation of water on the clay hardpan should prove beneficial.[1]

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[1] This condition is similar to that described by Hilgard (Soils, p. 162), except that here the effect is evidently due to the rise of soil water.

MISCELLANEOUS FERTILIZERS.

Analyses of various fertilizing materials, which have been made from time to time, are given below. The results are all calculated on the moisture-containing substance.

Analyses of fertilizing materials.

Materials.	Nitrogen (N).	Phosphoric acid (P_2O_5).	Potash (K_2O).	Moisture.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Goat manure	2.32	0.47	3.72	37.48
Do	1.92	.76	3.01	20.77
Sheep manure	1.26	.59	2.54	39.66
Seaweed	1.18	.16	.93	19.22
Cachasa (filter press residue)	.75	2.02	....	63.49

The advisability of using such fertilizing materials as the above depends upon their cost laid down on the place where they are to be applied. It should be borne in mind that it is so much nitrogen, potash, and phosphoric acid that is desired, and not the total bulk of the fertilizer. The cachasa is a waste product of sugar mills. In the dry state it should be worth, roughly, $12 a ton. In the state in which it is thrown out from the mill, two-thirds of the content being water, it is worth about $4 per ton.

ANALYSES OF LIMESTONES.

The composition of various samples of limestones, burnt lime, and marl from different parts of the island are given here. The following are samples of burnt lime. As these were sent to us in small packages, they were partially air slaked when analyzed. They are to be judged, then, on the amount of impurities they contain rather than on the percentage of CaO. The results are calculated on the moisture-free material:

Analyses of samples of burnt lime.

Locality where sample taken.	Silica (SiO_2).	Iron and alumina (Fe_2O_3 Al_2O_3).	Lime (CaO).	Magnesia (MgO).	Loss on ignition.	Total.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	
Guanica	0.12	0.20	68.45	Trace.	31.23	100.00
Tallaboa	.70	.48	67.38	.90	30.31	99.77
Cabo Rojo	1.35	1.21	70.18	2.23	25.11	100.08

It will be seen that the sample from Guanica is exceptionally pure, that from Tallaboa is also very good, and that from Cabo Rojo contains more impurities.

The following are analyses of disintegrated natural limestones. The results are calculated on the moisture-free material.

Analyses of samples of disintegrated limestones.

Locality where sample taken.	Silica, sand, and clay (SiO_2).	Iron and alumina (Fe_2O_3 Al_2O_3).	Lime (CaO).	Magnesia (MgO).	Loss on ignition.	Total.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Quebradillas	1.29	0.82	34.89	16.68	46.23	100.01
Do	.49	.51	34.76	18.17	46.57	100.40
Do	.20	.68	49.82	4.86	44.32	99.88
Pueblo Viejo			48.74			
Do	38.32	4.08	29.39	Trace.	28.53	100.32
Arecibo	3.29	1.15	53.36	Trace.	42.20	100.00
Bayamon	51.69	3.92	21.66	Trace.	22.24	99.51
Tallaboa	8.41	1.90	50.76	.84	38.81	100.72

These limestones are all as finely disintegrated as an ordinary soil and may be utilized for liming acid soils. Two of the samples contain such a large amount of sand and silica that they are of no value except to persons in the immediate vicinity of the deposits. The samples from Quebradillas contain much magnesia.

For correcting acid conditions one part of burnt lime probably has an action equivalent to five or six of a natural limestone, such as the above. This is merely an estimate based on the following points: Burnt lime, weight for weight, contains two times as much lime (CaO) as a natural limestone; burnt lime is more finely divided than these limestones; the action of the calcium oxid (CaO) of burnt lime is much more energetic than the action of the calcium carbonate ($CaCO_3$) of the natural product. The use of the natural, disintegrated limestone has the advantage that there is little danger from overliming.

The increased yields resulting from liming our acid clay soils renders the utilization of these deposits highly advisable. An acid clay soil of the station planted to sugar cane was much improved by liming. The data of this experiment follow.

There were five plats of one-twentieth of an acre each. The check plat received no lime nor fertilizer, one received 25 pounds of air-slaked lime, another 25 pounds of lime plus a complete fertilizer, another 150 pounds of lime, and the last 150 pounds of lime plus a complete fertilizer. The variety of cane planted was B1753. The yield of cane, calculated as tons per acre, was as follows:

Effect of lime on cane production.

Treatment of plats, rate per acre.	Cane per acre.
	Tons.
Check, nothing added	44.0
500 pounds lime	50.2
500 pounds lime and fertilizer	57.3
3,000 pounds lime	69.3
3,000 pounds lime and fertilizer	61.6

REPORT OF THE HORTICULTURIST.

By C. F. KINMAN.

CITRUS FRUITS.

The progress of the citrus industry for the past year has been very satisfactory. With the better understanding of cultural methods and a realization of the value of windbreaks the quality of the fruit produced is much superior to that of a year ago. A number of orchards just coming into bearing have yielded good returns. Some groves of 4-year-old grapefruit trees, having made a good growth, bore a crop of fancy fruit. Shipping of the native oranges which grow wild through the western part of the island did not begin this year until the fruit was in saleable condition, and during the early part of the season the fruit sold well, being recognized by the good buyers and selling along with the cultivated varieties. When the market returns showed good profits numerous unscrupulous shippers began exporting fruit which was too green for consumption and which had been so roughly handled that it reached the market in very poor condition. Such sales resulted in a great injury to the market for Porto Rican fruit. The same is the case almost yearly. If shipping of green and carelessly handled fruit could be prevented by law, it would be a great benefit to the fruit industry of the island.

Such a large amount of the uncultivated fruit decayed in transit to New York that an experiment to determine the percentage of damage due to injured fruits was made. The work was carried on in the packing house of the R. S. Hammond Fruit Co., who kindly furnished the fruit for the experiment. As it was late in the spring when the test was made the fruit was very ripe and had been badly injured in picking and hauling. The following classes of fruit were wrapped, packed, and stored in a room where the temperature ranged from 80° to 84° F.: One crate of fruit that had been bruised in bringing from the field, one crate of stemless but otherwise soud fruit, one crate of sound fruit, and one crate of fruits that had been pricked or clipper cut. At the end of 14 days the fruit was examined and the following notes were made: Of the box of bruised fruit 22 per cent had decayed, of the stemless 11 per cent, of the sound fruit 5 per cent, and of the pricked or clipper cut 38 per cent. Each decayed fruit was found infected with blue mold. This shows that here, as elsewhere, the main cause for the decay of citrus fruits is careless handling.

Fruit in a number of orchards ripened out of season this year, all of which brought a high price. As the summer and winter temperatures in Porto Rico vary so little it seems that at least in sections where the rainfall is well distributed throughout the year citrus trees may be brought into bearing either before or after the main crop has been shipped from California and Florida. Some experiments to determine the influence of fertilizers in this respect are under way both at the station and among the planters. (Pl. I, fig. 1.)

The fertilizer experiments that have been carried on for the past few years in cooperation with planters are being continued. The complete fertilizers are giving the best results again this year.

During the last year an orchard survey of the island was undertaken and is being carried forward as fast as possible.

From the planting of orange varieties the following notes have been taken: Fruit from the variety Early Oblong is this year of a very fair quality and flavor and of good appearance, while last year it was very irregular in shape, poor in texture, and of a very undesirable flavor. These trees are now 5 years old and bore their first crop last year. Selected native seedlings have made a more thrifty, upright growth than the imported varieties, and this year 5-year-old trees are bearing a fair crop of fruit. The tall growth is objectionable, as the tree tops are more exposed to winds and the picking of the fruit is more difficult. Hart Late has succeeded much better than any of the other varieties at the station. These trees, while bearing a heavy crop, remained very vigorous through the long and severe drought of last winter, and during the past summer they have shown no detrimental effects from the excessive rains. Rangpur limes, which ripened in December, 1909, were left on the tree and are in good condition one year later. A number of less commonly imported citrus types have fruited this year, none of which gives promise of being of interest commercially.

COVER CROPS.

The practice of growing cover crops at least during the season when the frequent rains prevent cultivation and on soils which wash badly is practiced quite generally in Porto Rico. Work to determine the best leguminous plants for this use is being continued. During the past year plantings were made of cowpeas, velvet beans, quar, crotalarias, a native species of Phaseolus, a cassia, lablabs, pigeon peas, and various native legumes. One planting of the above crops was made late in March on a sloping, very heavy, poorly drained soil. The rains were so frequent that no cultivation was attempted

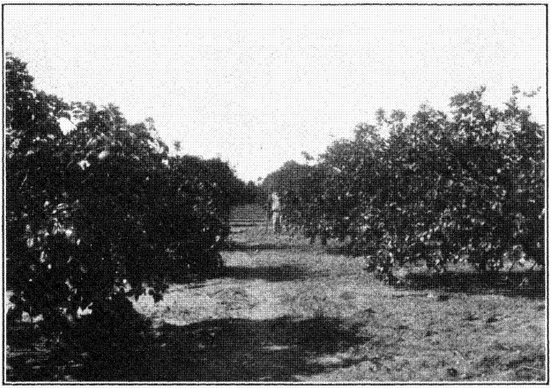

FIG. 1.—FERTILIZER EXPERIMENTS WITH ORANGES.

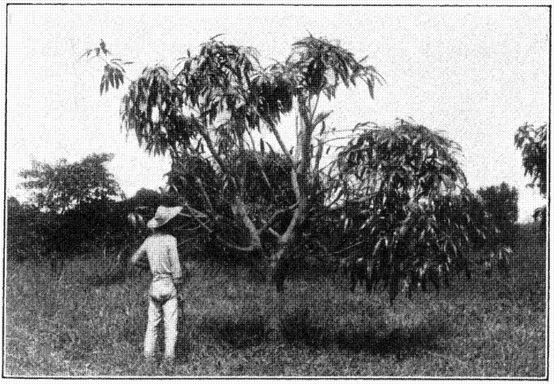

FIG. 2.—TOP-WORKED MANGO TREE.

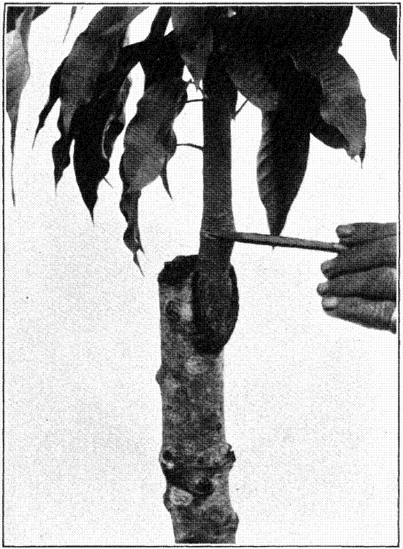

FIG. 1.—BARK-GRAFTED MANGO.

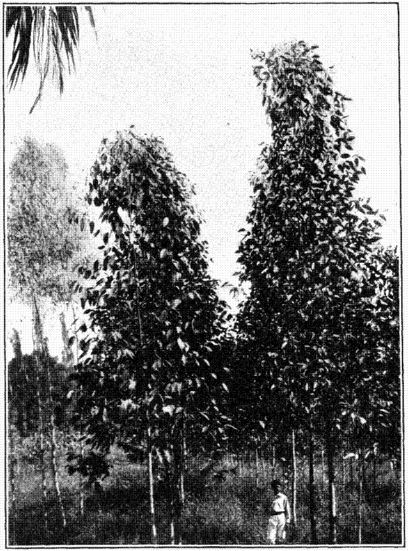

FIG. 2.—EUCALYPTUS PIPERITA AND E. ROBUSTA, 2 YEARS OLD.

after the first few weeks of growth. Under these conditions, both the Clay and Whippoorwill varieties of cowpeas did well, they being the first to cover the ground. This crop produces a good amount of vegetable matter, but matures in midsummer, which allows grass and weeds to grow during the remainder of the rainy season. The velvet beans did not cover the ground as quickly as the cowpeas or canavalias though they made a heavy growth and kept down all objectionable vegetation until late in the fall. The pigeon pea grew rapidly, reaching 8 feet in height. This plant, while not covering the ground as well as other crops, produces a good quantity of vegetable matter and is an excellent windbreak when planted near young trees. *Canavalia gladiata* made the most rapid and vigorous growth of any of the crops. It covered the ground in a few weeks after planting and smothered all grass and weeds. This plant continues its vigorous development until checked by the drought of the winter. Its extensive root system with its heavy top growth makes it valuable for lands injured by washing, though its vining habit is often troublesome in an orchard. The growth of the other legumes did not indicate that they would be of value as cover crops under the conditions, but they will be tested further. A planting has been made to test these crops during the winter months. Though the weather conditions have been good the plants have made a very poor start for these first two months, the velvet bean making the most satisfactory growth.

MANGOES.

Sixteen varieties and 21 seedling types have been added to our variety planting during the past year. With these additions the station now has growing 62 varieties, besides the numerous seedling types. Of the varieties set in 1904 and 1905, Sandersha, Ameeri, Cambodiana, Mulgoba, Totafari, Bulbulchasm, and Mulgoa fruited this year, this being the first crop for the last four. Sandersha was the most prolific variety, single trees bearing from 60 to 190 large fruits. Cambodiana and Bulbulchasm were considered the best in flavor. The fruit flies, which ruin all fruits of some types of native mangoes, injured many fruits of the variety Cambodiana and a few of those of Sandersha when they were allowed to ripen on the tree. This fly is such a serious pest that varieties attacked by it can not be recommended until a means for its control has been found.

Experiments in propagation have been continued, including inarching, budding, bark grafting, and growing seedlings from various superior fruits. (Pl. I, fig. 2.) Bark grafting both young and old trees gave good results, and at least for old trees this method seems to be most satisfactory. (Pl. II, fig. 1.)

The fruits from the varieties Sandersha, Ameeri, and Cambodiana were used in experiments to test the time for picking, methods of

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Plant Industry of the United States Department of Agriculture. When the cuttings had made sufficient growth they were removed to the field, where most of them have since died. None made a satisfactory growth. This is no doubt due to the unfavorable soil condition, as thrifty vines are found in various places over the island.

The present plantings of Eucalyptus are confined almost entirely to the flat, poorly drained soils, under which conditions the various varieties show considerable difference in thriftiness. *E. piperita* and *E. robusta* have made the best growth. *E. robusta* trees two years from planting are 29 feet tall, having grown 13 feet during the past 12 months. (Pl. II, fig. 2.) *E. piperita* has grown slightly faster. These varieties, as well as all others under observation, have made much slower growth on one side of the field, where the drainage is somewhat poorer than on the other.

Experiments with seed beds, transplanting, etc., are being continued.

REPORT OF THE ENTOMOLOGIST.

By W. V. Tower.

During the past fiscal year a number of new entomological problems have been taken up, among them the study of an injurious ant found in coffee and one of its shade trees, the guama, and of various insects injurious to the guava.

Much time has been devoted to the study of the Lachnosterna beetle found in the cane fields. Many fields have been visited from time to time, and a great number of cooperative experiments have been carried on during the past season. Many valuable data have been brought together regarding the life history, periods of flight in different sections of the island, food plants of adults and of the larva, and conditions most attractive to the laying adult.

Many experiments have been made to combat the grub and the beetle. A parasitic mite has been found on the larvæ, and its work is being watched with great interest.

GUAVA INSECTS.

There seems to be an unusual number of insects which attack the guava; among them are leaf eaters, fruit curculios, fruit flies, and scale insects. The most destructive insects to the crop are the fruit flies and two beetles which pass their larval period in the growing fruit; one is a large beetle which develops in the blossom, using the flower as its food; the other passes its larval period in fruits ranging in size from ¼ to 1¼ inches in diameter. Most of the fruits in which these insects have been found have become black and mummified. Hundreds of mummified fruits have been examined, and a very high per cent contain the larvæ of a small snout beetle, or the fruit shows that it has been eaten by it. The larva bores into the dried, fleshy part of the fruit and also into the flesh surrounding the seeds. The fruits are stung when they are small and still green.

The guava-fruit fly in Porto Rico is very destructive, and practically all the ripe fruits are infested with this pest. This insect is being studied, and it is hoped to find a period in its life history when it can be successfully destroyed. The eggs are laid when the fruits are still green, and when they are dead ripe the larvæ are ready to pass to the ground, where they pupate. The larvæ destroy the fleshy parts of the fruits and are also found feeding on fleshy matter between the seeds.

COFFEE INSECTS.

An ant has been causing a great deal of trouble in coffee and coffee-shade trees during the past year. Although no remedy has been found, many interesting points have been observed concerning its habits and food supply. The ants live in the coffee-shade trees principally, but some colonies have been observed in the coffee itself. They obtain their food from the honeydew secreted by two species of scale, one the common mealy bug and the other a very large, fleshy scale, pinkish in color. The scales are often kept in the canals which are cut by the ant in small branches and twigs of the shade trees and also in the coffee trees. They also carry the young of the scale and deposit them on the leaves; this has been noted on coffee which has been under observation in the laboratory.

These insects seem to prefer the guama shade tree as their host plant, but are also found living on the ground in the dry twigs of coffee and guama. Experiments with tanglefoot and with repellents have been tried, with varying results.

CITRUS FRUITS.

Experiments in the fumigation of citrus trees were carried on during the year. The percentage of dead insects found on trees after fumigation was very great, only 0.5 per cent being alive. The object of the work was to compare results of fumigation with spraying in the Tropics. The experiments were very successful and will be continued.

Fruit growers are taking up the work of protecting their groves from the wind, and the indications are that they are going to have very much cleaner fruit, the scale being taken care of by the beneficial fungi. The importance of planting windbreaks is continually being urged by the station, not only the quick-growing kinds, but strong, hard-wooded trees that will become permanent breaks to withstand the winds and storms of years.

BEES.

There continues to be great interest in apiculture. Many of the coffee planters are sending men to the station to study methods of beekeeping. During the summer a class of 15 was studying the practical handling of bees, methods of raising them, and the production of honey. The station has sold during the last year a number of nuclei, most of them being sent to coffee estates in the interior.

At the present time there seems to be a very bright future for the bee industry in Porto Rico, as there are no diseases, and where Italian bees are used the moths are not troublesome. It is important to remember that the stock or the strain must be kept up or bees will become mixed with the black bees, which are not so good as honey producers. When new blood is desired queens only should be imported by mail, as bees brought from other countries are apt to be diseased.

At the last session of the Porto Rico Legislature the following bill was made a law:

> That no bee comb, larvæ, pupæ, or bees shall be brought into Porto Rico from any other place: *Provided*, That queen bees, accompanied by not more than 30 worker bees and without bee comb containing eggs, larvæ, pupæ, or bees, may be introduced therein in mailing cages, or small boxes.

A circular on beekeeping in Porto Rico has been prepared and will soon be ready for distribution.

INSECT PESTS IN CUBA.

June and July of 1910 were spent on the island of Cuba, the expenses of this trip being borne by some of the sugar planters of Porto Rico. The main objects of the visit were to study the cane insects and to obtain, if possible, parasites of the Lachnosterna beetle found in Porto Rico canes. Cuba, no doubt, has this same beetle, but only two specimens were found, one in the collection at Santiago de las Vegas and one in the Gundlach collection at Habana. Many of the planters recognized the beetle from descriptions given and all stated that their flight occurred during March, April, and May, the same time as their flight in the district of Mayaguez, P. R. The flight of this beetle was the same in all parts of Cuba visited—Santiago de Cuba, Habana, Ceballos, Cienfuegos, and Manzanilla. This seems a little strange, as in Porto Rico we have the Mayaguez flight in March, April, and May, while the Guanica flight is during May, June, July, August, and a part of October.

Cuban methods of planting are very different from those practiced in Porto Rico. On new lands the wood is cut and burned. The canes are planted in rows as closely as possibly; no holes are dug, no plowing done, and no stumps removed. The fire kills all the weed seeds, and the first crop comes on very quickly and does not need very much, if any, cultivation.

When canes are cut and the rattoons commence to come up the trash is pulled away from around the stool, and after a certain length of time placed back again, the trash protecting the ground, so that very few weeds have a chance to grow. Although this is not the way all cane is grown in Cuba, it is the usual practice on virgin lands. Often after the first year the cane fields become infested with Johnson grass, which it is very difficult to get rid of. This is one of the plants whose introduction into Porto Rico must be avoided. There is one serious drawback to this system of cropping, and that is that the accumulation of so much trash makes an ideal place for insects and fungi to breed. An examination of the trash showed a great amount of animal life and fungi, especially root fungi. The Cuban fields which have been in cane a number of years are full of root fungus. The trash was full of canes, which showed that they had been killed by the West Indian rind rot. One reason why Cuba has not had a severe outbreak of diseases is that when the lands become infested they are left, and virgin lands, or lands which have been lying idle for a number of years, are planted.

The cane insects of Cuba are about the same as those of Porto Rico. Canes were seen which had been eaten by the moth borer, shot-hole borer, and the weevil borer. These insects were more abundant in the Cuban fields than in the cane fields here. There seem to be two reasons for this: One is that some years not all the crop is harvested, and the other is that the Cubans cut their canes too high, sometimes leaving from 1½ to 3 inch stubs. This seems a very poor practice, as the planter loses a certain amount of sugar; also, the stalks or pieces of cane make ideal places for fungi and insects to obtain a start. In many fields stools examined showed that the stubs of cane had been destroyed in some cases by fungi, and others showed that insects had cleaned up the canes, as they were, at the time of examination, full of fiber and the cocoons of the cane weevil. On some of the estates visited these conditions did not prevail. They were cultivating their canes, planting legumes between the rows, testing systems of planting, and in some places irrigating. At these estates the canes looked remarkably well, and the tonnage was far above the average Cuban crop.

Cuba's most serious orange troubles seem to be the extended drought which comes during the winter months and the small weevils which scar the fruits. After the first rains in the spring the trees blossom and the weevils appear. The scarring is done by several species. A number of these beetles were collected, and the planters stated that all of them injured the fruit. A number of specimens were seen eating the young fruit of the second blossoming. The fruit of the first blossoming was very badly scarred. Not very much scale was observed, as the groves visited were protected by the beneficial fungi, which were in great abundance. Cuba apparently has not as strong trade winds as Porto Rico, and for this reason alone the scale would not be as bad. Another reason why Cuba does not have a great amount of scale is that many of her groves were originally planted in strips cleared in the forests.

The treatment of orange groves in Cuba is not the same as in Porto Rico. The general practice is to allow the grass to grow in the groves during the rainy season, cutting it as it grows high, and saving it for a mulch to place around the trees during the winter months. This has been practiced during the past season by many, and good results have been shown.

REPORT OF THE PATHOLOGIST.

By G. L. FAWCETT.

COFFEE DISEASES.

The leaf blight of coffee caused by *Pellicularia koleroga* has been studied during the past year. Especial attention was paid to the life history of the fungus. No ascus-bearing stage was found nor any evidence of propagation by spores. A slow but effective spread of the disease takes place by the dropping of leaves carrying the mycelium or their transportation by the wind to healthy trees, each infested leaf being a source of infection. The fungus makes rapid growth during the season of abundant rainfall, but with the dry season its growth stops, and it gradually dries up and falls away, leaving the trees comparatively clean. Small fragments remain, however, and from these growth is again made when sufficient water is available. It is at the close of such periods of drought that sprayings can be made most successfully. In experiments made here during the past season various fungicides were tested as sprays, several with favorable results. Bordeaux mixture was found to be best, owing to its adhering better to the foliage. Spraying, together with cultural methods, such as careful pruning and the avoidance of too close plantings, promises to control this disease effectually.

More difficulty is encountered in the case of the so-called root disease of coffee, in which the trees are killed by being girdled just below the surface of the soil. At first the disease affects a small area, but gradually and slowly spreads. Although acting so slowly, the total loss is great, especially as the best trees are often attacked. The trouble seems to be favored by the piling up of earth about the base of the trees, especially below hillside paths, and by the accumulation of masses of decaying vegetable matter. Various methods of soil disinfection are being tried, and ditches have been made to prevent the spread of the diseased areas. The experiments will have to be continued through a considerable period of time before obtaining results of any value.

The spot of leaf and fruit caused by *Stilbum flavidum* is really a serious disease of coffee though fortunately restricted to the area of extreme humidity. The life history of this fungus, never fully worked out hitherto, has been studied and an experiment in its control begun. Work has also been done on other minor diseases of coffee on which a report will be made later.

PINEAPPLE DISEASES.

The cultivation of pineapples in the clay soils of some of the more humid regions is attended with uncertain results. Sometimes the plants during the second or third year after being set out become yellow and do not respond to the usual applications of fertilizer. The roots of such plants have been found to be decayed. An experiment in soil disinfection, making heavy applications of several disinfectants, was carried out in one of the worst affected fields, but without favorable results except in the case of one plat, to which sulphur was applied. Potted plants have not shown any symptoms of this disease nor lost any part of their root systems, though inoculated with a Fusarium common in the diseased plants and in some cases placed in contact with material from these plants. That the inoculated and check plants are equally healthy is probably because it was impossible to duplicate the physical conditions of the field soil. This subject will be studied further, but it would seem now that fungi and bacteria are unable to injure the plants unless soil conditions are very unfavorable.

MISCELLANEOUS DISEASES.

A disease quite common in one variety of bananas is caused by a fungus which enters through the root and attacks the stem. The fungus, a species of Fusarium, was isolated and a study made of the disease nearly two years ago, but, as the banana is one of the lesser crops and the disease is only occasionally troublesome, no further attention was given to the subject until early in the present year, when serious loss was reported on one of the plantations, which, on investigation, was found to be caused by the same disease as that previously studied. Experiments to determine effective methods of control have been begun. The disease is apparently identical, both as to the causative organism and general symptoms, with a disease very destructive in the banana plantations of Central America.

The diseases of some other plants have been studied so far as time permitted. Among these may be mentioned a bud rot of the coconut, which is found in a few trees in some of the plantations along the west coast. It seems to be identical with the bud rot occurring in the other West Indies, though evidently less contagious. Some attention has been given to the diseases of cane and cacao, though no report will be made until the conclusion of experiments now in progress.

REPORT OF THE COFFEE EXPERT.

By J. W. van Leenhoff.

Weather conditions were very unfavorable during the past year at and in the vicinity of the coffee substation at La Carmelita. Severe storms during August and November destroyed all hopes for a good crop and for the showing of definite results in the various experiments. The disastrous results of the strong winds could be seen, the soil under and between the coffee trees being literally covered with small coffee plants sprouted from berries blown from the trees. The berries were larger than last year and ranged from 300 to 350 berries per liter.

The emajagua, *Paritium tiliaceum*, planted for windbreaks, is growing well and will soon be in condition to stand a test, but the pavonia, *Hibiscus rosa sinensis*, could not be planted in sufficient quantities because of the difficulty of procuring seedlings.

The new plantings of Porto Rican and foreign coffees continue to do well, and the crop was again used for distribution free of charge to planters and for cup tests. Several samples roasted here were sent to different persons in the States and on the island. Nearly all reports from the cup trials agree as to the excellency of the Maragogype coffee.

The United States market has thus far refused to buy Porto Rican coffees, and one of the reasons for this refusal is said to be a bitter taste of the coffee, to which customers in the States object. The removal of this bitter taste would therefore be a valuable improvement and likely to facilitate the introduction of the coffees into the home market. The successful shipping of roasted coffee from here direct to customers in the United States might open a new field for commerce.

A few trees of an exceedingly fine coffee, Mocha or Inhamban, were discovered in the neighborhood of Mayaguez. Some seeds were collected and planted, with the hope of introducing the cultivation of this fine coffee amongst our planters.

Leaf weevils are still doing very much damage, and experiments for their control have thus far not been successful. The American coffee disease (*Stilbum flavidum*) is rapidly spreading in the vicinity. A special study is being made of this disease by the plant pathologist, and experiments for its control have been begun. Coffee leaf blight and borers in the shade trees continue on the increase, and thus far no means have been found for their control.

IMPROVEMENT OF AN OLD COFFEE GROVE.

The experiments on the renovation of an old coffee grove were continued, but owing to the heavy losses of berries by storms, no positive results can be shown. From the 9½-acre tract 2,468 pounds of coffee were harvested and marketed. The collection of data on the cost of producing coffee in the improvement plats has been continued.

Cost of producing 100 pounds of coffee in renovating experiments, 1910.

Weeding, pruning, etc	$2.70
Harvesting	1.56
Preparing for market	.60
Freight to market	.39
Total cost per 100 pounds	5.25
Average price obtained per 100 pounds	11.03

EXPERIMENTS WITH NEW PLANTING.

A definite report on the experiments to determine the cost of producing a coffee plantation can not be presented, for the reason that the great demand for coffee seed and the large quantities of samples sent out for cup tests made it impossible even approximately to determine the quantity harvested. Besides the seed and samples, there were gathered 163 pounds, which were sold for $18.14.

REPORT OF THE ASSISTANT HORTICULTURIST.

By T. B. McClelland.

Some experimental tappings of 7 and 8 year old Castilloa rubber trees on the station grounds were made. All tappings were made by the herringbone system. On April 15 one of the largest of the 8-year-old trees was first tapped, giving 40 grams of dry rubber; on April 18, the wound being shaved, the yield was 18 grams; being shaved again on April 20 only 10 grams were obtained; making a total of 68 grams of dry rubber. In August all of the trees which were 24½ inches or more in circumference at 3 feet above base, greatest girth being 32 inches and average girth 28⅓ inches, were tapped between 5.15 a. m. and 8 a. m. The main channel cut was about one-half inch wide, shallow, and 6 feet in length. In most cases there were four branch cuts on either side 6 to 8 inches in length, made fairly deep but narrow. The latex did not flow very freely and tended to coagulate on the tree. The incisions made on the tree tapped in April seemed to have widened, if anything, rather than to have made a successful effort at closing the wound. New incisions between the old scars gave almost no latex, but a good flow was obtained from the other parts of the trees, showing the unsuitableness of the herringbone system for Castilloa, as so much of the trunk is covered and the cuts must heal before the areas are retapped. A tree which was tapped on the opposite side the second day after the first tapping gave for the first tapping 16 grams and for the second 39 grams, showing the much greater pressure thrown by tapping into the untapped side. The relative amounts of dry rubber bore no relation to the quantity of latex, one tree yielding 22 grams of dry rubber from less than 100 cubic centimeters of latex, another 17 grams from 400 cubic centimeters of latex. Fourteen trees were tapped, all together yielding in one tapping 279 grams of dry rubber from latex and 70 grams of scrap, or about 25 grams per tree.

Some additional plantings of rubber have been made, including *Mascarenhacia elastica*, *Funtumia elastica*, and *Castilloa* sp.

The vanilla cuttings received in December of last year were somewhat retarded in starting by the long-continued drought which commenced about the time they were planted. They are, however, now in flourishing condition, and several vanillas growing wild in different parts of the island have been added to the collection.

Notes on cacao as to yield and comparative notes on different trees are being kept. The plantings now include some 15 varieties.

Most of the young coffees planted last year are doing well, excepting, however, some planted on a very steep, badly washed slope and which are very much exposed to the sun. Among the young coffees, Padang and Columnaris are doing best. Both Blue Mountain and Ceylon hybrid coffees, which were set from seed bed two years ago, gave very good yields this year, a number of trees in each producing more than a pound of dry coffee. Seed of these and of a few other introduced coffees were distributed to numerous growers. (Pl. III, fig. 1.)

The value of cover crops, manure, various chemical fertilizers, and terraces and ditches on steep slopes to prevent washing are being tried. The experiments as to the manner of and age at which transplanting to permanent location had best be done are being continued, and tests are being made as to the value of applying various amounts of lime to the soil at time of transplanting.

Last year high-growing coffee trees which had lost their lower branches were cut off at distances varying from a few inches above ground to 6 feet. From the renewed growth it seems advisable to cut the trees as low as 6 inches, since in any case the greater part of the crop is lost, only a very few berries being left even when the trees are cut at 6 feet. (Pl. III, fig. 2.) The lower the trunk is cut the lower will be the renewals and the fruit-bearing branches. Some topping experiments have been started on young coffee which has not lost its lower branches. Work is being continued on getting an old plantation into young, lower, and more productive wood rather than leaving old and high-branching trees as they are to bear coffee out of reach of the pickers.

As this plantation is shaded by the ant-infested guama, *Inga laurina*, plantings of numerous leguminous trees were made, which included, besides the native trees, *Albizzia moluccana* and *Pithecolobium saman*, with the idea of eventually eliminating the guama. On the station grounds *Pithecolobium dulce* and *Albizzia stipulata* are also being tried as coffee shade.

Germination tests of coffee and various methods of preserving the viability of the seed are being continued and will be reported upon later.

New plantings have been made of Murta, Kamerun, Hawaiian, Mauritius, Menado, Surinam, and Philippine coffees.

Some work is being done on hybridizing coffees, and at present some small seedlings of *C. arabica*×*C. liberica* and of *C. maragogype*×*C. arabica* are on hand.

REPORT OF THE ANIMAL HUSBANDMAN.

By E. G. Ritzman.

The work in animal husbandry in the past was, from necessity, primarily limited to the introduction and acclimatization of improved breeds of live stock. As nearly all improved breeds have been brought to their present state of perfection in the more temperate climates, it can easily be seen that such work presents many new problems in the Tropics. It is necessary to bring in stock that will meet the economic conditions of the island and which will best suit other conditions prevailing here.

Climatic conditions differ materially in various parts of the island, owing mainly to the great difference in rainfall. Soil conditions are widely different, and the natural result is that by reason of climate, soil, and vegetation some sections are more favorably suited to stock growing than others. The rainfall is very heavy at the station, ranging from 70 to 90 inches annually, and the soil is deficient in lime. The south side of the island, on the other hand, is comparatively dry, the grasses are more nutritious, and the soil is richer in lime. These conditions prevail also to a certain extent in some localities on the northwest coast. The south side is, therefore, by nature more favorable to stock breeding, and it is there that the larger numbers of stock are bred, especially horses and work oxen.

It is yet a question as to whether it is safer to import young growing stock or mature animals. It can be stated tentatively that in this part of the island mature stock does better, while in the drier sections it would be safe for both young or old. Young stock acclimates quite readily, but old stock will thrive on less nutritious food, especially so far as concerns mineral nutrition. This is well illustrated by a comparison of the stock-breeding industry in the limestone regions of the north with other parts where limestone is less abundant.

Incidental to this work much time has been spent in the erection of suitable buildings, the preparation of paddocks, and in the care and management of the imported stock. From necessity it has involved a study of diseases, their prevention and treatment, with general observations on sanitation. Varying with local conditions, the problems of feeding demand a study of the available feedstuffs and their suitability to supplement the forage crops grown here.

With the progress of time the work is becoming more encouraging, and breeders are now making a demand for improved standards in the live-stock industry.

HORSES.

Trotting-bred, thoroughbred, and saddle-bred horses have been introduced on the south side of the island, and, as has been stated in previous reports, with the result that a material increase in the size of the stock has already become apparent. The demand for larger horses, especially for the carriage type, is becoming stronger as the agricultural conditions are improving, and good horses command high prices.

The greatest difficulty in making introduction of stock by the station has been encountered with horses. This is largely due to the unfavorable climatic and soil conditions which exist in this part of the island where the experiment station is located. Of the six horses brought from the States during the previous year, three became affected with osteoporosis within four months after their arrival. The animals affected were all yearlings. They were immediately treated with small doses of potassium iodid, and an attempt was made to offset the loss of calcium by giving calcium chlorid in the drinking water or the food. Apparently beneficial results followed in two cases. The two older animals which had reached maturity when brought down have kept in excellent health. As ticks were found on the affected animals, it has been suggested that they may have some relation to the disease. The three older stallions are now in the stud on the south side of the island, two in Coamo and one in Ponce.

The prevalence of glanders is a great drawback to the horse and mule industry here. With proper sanitary measures to prevent further contagion, it could no doubt be eliminated. It exists apparently in a chronic state among native stock, but a number of American mules brought down by sugar planters have contracted an acute form. The station has so far been free from this disease.

CATTLE.

The chief demand for improved breeds of cattle continues to be for those of the dairy type. Breeders are especially desirous of securing the use of sires of deep milking strains. There have been added to the station herd a Jersey bull calf and a 2-year-old Guernsey bull. The four crossbred Zebu bulls brought from Texas last year are now of breeding age, and have been put at the service of breeders on the south side, where draft oxen are principally grown. They are very active, strong-boned animals, and should therefore add some very desirable qualities to their progeny. Although showing a tendency to be somewhat wild, they were broken to yoke.

Results so far obtained from crossing native cattle with improved beef breeds indicate a prepotency of the improved blood, but only the best type of native cows should be used, else the results may be disappointing. The station now has several head of such crosses. A Hereford cross with her second calf, though a very poor milker, is a very pretty animal, with more spread of frame than her dam and better beef form.

Diseases among cattle are not very prevalent. The greatest damage comes from the ticks, which at certain seasons tend to keep the cattle somewhat emaciated. A disease somewhat resembling apoplexy in its symptoms, locally known as "llaga," occurs not infrequently. Blackleg has occurred periodically in certain sections, but is being combated by the use of vaccine. Minor affections, such as grubs and parasites from stagnant water, are apt to become troublesome if not promptly attended to.

HOGS.

The demand for pure-bred hogs for breeding purposes has been steady throughout the year. Thirty head were sold during the year. The principal drawback to the development of the hog industry is the scarcity of proper feedstuffs and the high cost of those available, together with a lack of knowledge of the principles of feeding. The work in mineral nutrition with pigs begun last year has been continued, and the results will soon be published.

SHEEP.

In crossing the African woolless with native sheep the result in the majority of cases showed a dominance of the characteristics of the white native, except as to wool. Native sheep possess a poor mutton form, and in the majority of cases a very patchy, inferior fleece. The African sheep has brown hair, and males usually possess horns. As a mutton sheep, they also leave much to be desired. A Southdown ram has been added to the flock, and an attempt will be made to produce a sheep that retains the mutton qualities of the Southdowns with hardiness of the African sheep.

An attempt was also made during the year to graze sheep in coffee land. If successful, it would solve a problem of cheap pasturage and at the same time add fertility to the soil. It was soon found to be impractical, as some weeds or grasses were injurious to the sheep. Four lambs became very sick, two of them died within a week, and the others soon afterwards, and the whole flock was out of condition for some time. It was found that they did not attack coffee where other good grazing was available, but as soon as pasture ran low they ate young twigs and leaves. There has been some demand for African sheep for breeding purposes, and 17 head have been sold to various parts of the island during the year.

POULTRY.

The demand for eggs and poultry during the past year has been very strong. Forty-two chickens, barred Plymouth Rock and single-combed White Leghorns, have been sold for breeding purposes. In addition, 14 head of Pekin ducks and about 150 settings of eggs of these breeds and of Bronze turkey and Toulouse geese have been sold for a similar purpose.

No disease has so far affected the grown poultry, but considerable loss has occurred from sorehead among young stock. Many young chicks have been saved by treatment with tincture of iodin. This treatment, however, must be applied with great care.

STOCK FEEDS.

The high prices of concentrated stock feeds is at present a great drawback to the live-stock industry in Porto Rico. This naturally applies more to some classes of stock than to others. Hogs, for example, can not be developed at their best without concentrates, and poultry will not produce without a proper balance of nutritious food. The supply kept by dealers is somewhat limited in variety, chiefly owing to the small demand for such feeds. Stock growers have not yet learned to select feeds which are best suited to certain purposes or to balance rations. Corn, about the only grain crop grown, forms the basis for poultry feed, and it is used largely for horses. Hogs, on the other hand, live largely on kitchen slops, fruits, and seeds from the royal palm. Corn often retails at prices which are much higher than the cost of slaughterhouse and milling by-products if their relative feeding value is considered. It is not likely that a local production of concentrates will develop. Forage crops, however, could be grown to some extent to supplement in part the present scarcity.

When planters come to appreciate the relative value of different stock foods they will be able to grow their stock more economically as well as to produce better animals.

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Issued September 3, 1912.

PORTO RICO AGRICULTURAL EXPERIMENT STATION,
D. W. MAY, Special Agent in Charge.

ANNUAL REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION FOR 1911.

UNDER THE SUPERVISION OF
OFFICE OF EXPERIMENT STATIONS,
U. S. DEPARTMENT OF AGRICULTURE.

WASHINGTON:
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PORTO RICO AGRICULTURAL EXPERIMENT STATION.

[Under the supervision of A. C. True, Director of the Office of Experiment Stations, United States Department of Agriculture.]

Walter H. Evans, *Chief of Division of Insular Stations, Office of Experiment Stations.*

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LETTER OF TRANSMITTAL.

Porto Rico Agricultural Experiment Station,
Mayaguez, P. R., December 21, 1911.

Sir: I have the honor to transmit herewith and to recommend for publication the Annual Report of the Porto Rico Agricultural Experiment Station for the fiscal year ended June 30, 1911.

Respectfully,

D. W. May,
Special Agent in Charge.

Dr. A. C. True,
Director, Office of Experiment Stations,
United States Department of Agriculture,
Washington, D. C.

Publication recommended.
A. C. True, *Director.*

Publication authorized.
James Wilson,
Secretary of Agriculture.

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ANNUAL REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION FOR 1911.

SUMMARY OF INVESTIGATIONS.

By D. W. May, *Special Agent in Charge.*

INTRODUCTION.

During the year great progress was made and a large increase shown in the production of the island. This amounted in value to over $10,000,000 above the figures for the previous year. The trade of Porto Rico has shown a steady increase since the American occupation, growing from $16,600,000 in 1900 to $78,700,000 in 1911. While the trade with foreign countries has grown, that with the United States has increased at a much greater rate. Porto Rico's purchases from the United States were exceeded by only 12 foreign countries, and were greater than those of Hawaii, Alaska, or the Philippines.

Of the $40,000,000 of exports, agricultural products, raw and manufactured, made up the entire sum. Sugar still leads the list, but there is a greater proportionate gain in some other products. Among the manufactured products tobacco stands first. Cigars in excess of $5,000,000 were exported. Other manufactured products were preserved fruits, straw hats, and distilled spirits.

The weather conditions of the year were good; in fact, crop failures in Porto Rico are unknown. It is true that on the south side of the island there is usually a shortage of rain for the best growth of the sugar cane, but with the development of irrigation systems a crop is assured even here at all times. The increase in the production of the island has been due to better cultivation and fertilization rather than to the extension of the area planted. The better cultivation has been brought about by a study of conditions and the extended use of machinery. Labor in general has been plentiful and is considered cheap. It is getting scarce in some industries and, moreover, it is not cheap as compared with efficient machine labor. The man with the hoe at 50 cents per day can not compete with the man with the plow at $3 per day. The real way to economize labor is by placing machinery in its hands.

Porto Rico purchased during the year over one million dollars' worth of fertilizers. That a return for this outlay was received there is no doubt. It is very important, however, that individual planters make a more thorough study of the fertilizer needs of their soils, with the object of getting a greater profit on the outlay under this head. There is need in Porto Rico for an efficient fertilizer law as, judging from some analyses made by the station, there are fertilizers sold in the island which are below the claims made and not worth the price paid for them. In lieu of a good inspection law planters should combine, as some have done, in the purchase of fertilizer materials. They can thus buy in larger quantities and afford to have analyses made. In some cases they can profitably mix their own fertilizers and reduce the cost. This has an added advantage in the fact that it induces planters to make a closer study of their soils and secure a more economical improvement.

The trend of agriculture in the island is toward more intensive methods. The cultivation of tropical soils is expensive. This is due to their heavy nature, but more especially to the rank weeds and grasses with which the cultivator has to contend. In countries above the frost line a start is made each season with clean land. In the Tropics it is not so, for vegetation is always present, and to subdue the land requires greater effort. Steam plowing may cover the grass and weeds deep enough to cultivate and plant at once, but in plowing with animals it requires several breakings and cultivations to subdue the wild growth and put the ground in condition for planting.

Steam plowing is carried on to a great extent by the larger companies engaged in sugar planting. The cable plow is more in favor, as it operates to better advantage in cane fields, which are still crossed with many surface ditches for drainage. Perhaps lighter plows with gasoline power could be used in some areas. The drawback to the cable plow is the large original cost of the equipment. When tile drainage is more generally practiced in Porto Rico, as it should be, traveling power plows can doubtless be used to advantage.

The station lowlands have been drained with earthen tile made on the property. The tile have been in operation seven years and are a success. During the year a machine which makes cement drain tile at a greatly lessened cost was purchased. The making of cement tile can be carried on during rainy weather, and 2 men can operate the mill, while 10 men are required to make clay tile. Moreover, the burning of tile, where wood is scarce, as it is here, is expensive.

In the cultivation of Porto Rican soils, then, great improvement can be made along the following lines, namely: By better cultivation, with the substitution of machine for much of the hand labor; by better and more economical fertilization, to be brought about by individual study of each plantation; by tile drainage in wet lands and more irrigation in the dry sections.

SUGAR CANE.

Sugar cane, the principal crop of the island, showed some increase in production during the year, and the crop generally was good. There was some extension, mainly in the interior valleys, and several small mills were erected. Good profits in the sugar industry cause an extension to less profitable lands, sometimes without due consideration. The expansion of an industry usually follows a prosperous year. Investors do not always take account of unfavorable years. While profits in sugar since the American occupation have been large, yet sugar production is a precarious business, and without the sustaining tariff it would require greater skill and study than is now employed to keep the industry from lapsing into the condition prevailing during the Spanish régime. That the more progressive planters realize this is shown by the increased study of improved methods and the applications of science to their industry. This is best exemplified in the recent establishment for the study of problems of sugar production of the sugar planters' station, which is supported by a tonnage tax on the industry.

The breeding and the introduction into Porto Rico of new varieties of cane will undoubtedly greatly improve the yield of sugar. Permanent irrigation works on the south side of the island and tile drainage on the north will also mean much for sugar production in the island.

COFFEE.

The coffee crop during several years has varied with the character of the season. Comparatively little coffee has been planted, but there is better cultivation of the old plantings. There will continue to be an improvement in methods and in the quality of our coffee, but it is not likely that there will ever be any great extension of the industry in Porto Rico. It is true that the increased price of the last year has given some encouragement to coffee growing, but other economic factors are causing a gradual change in the agricultural production of the island that is every year more manifest. Coffee is a crop for outlying districts, for, being a compact, nonperishable product, it may be profitably transported long distances over bad roads and mountain trails. Porto Rico is coming every year closer to the door of New York, the best market in the world. With better steamer connections and the extension of macadam roads throughout the island, the lands become more available for diversified crops. With quick and frequent means of transportation perishable crops become more remunerative. This is having its effect on the coffee industry, and there are many evidences of a change of coffee plantations to fruit orchards. The areas planted to pineapples and citrus fruits, and even cane, are encroaching upon the coffee plantings. It is contrary, too, to the best practices in agriculture to replant a waning crop on land that has produced it for many years. Moreover, coffee stands almost alone as the one crop lacking the stimulus of a customs tariff, while the sugar and fruits of Porto Rico are favorably treated in that respect.

TOBACCO.

Porto Rico exported tobacco during the year to the value of almost $7,000,000. By far the greater part of this was manufactured. Unmanufactured tobacco to the value of $1,500,000 was exported and $360,000 worth was imported.

The manufacture of tobacco has increased at a greater rate than its production. A larger number of persons are engaged in it than in any other manufacturing industry on the island. The people are singularly adept in the manufacture of cigars and cigarettes, and while the best tobacco lands are perhaps already closely planted, there will doubtless be a much greater increase in the manufacture of tobacco.

FRUITS.

The growth in the fruit industry in Porto Rico during a decade has been nothing short of marvelous. From nothing it has grown to a shipment during the year of over $1,800,000 in value. The planted groves are really only just beginning to bear. Fruit growing is destined to be one of the leading industries and in a few years it may surpass sugar in the value of the output.

The grapefruit of Porto Rico is meeting with great favor, and the quality of the oranges will become more evident as the trees grow older. Prices for citrus fruits as well as for pineapples have been satisfactory during the year. The prices for pineapples have been so favorable for the whole fruit that a smaller proportion than usual has gone to the canneries.

The problems facing the fruit grower appear less formidable than in the earlier years of the industry in Porto Rico. Many mistakes may now be avoided and groves brought into better bearing at a lower cost. The importance of protection from wind is now fully appreciated, and more careful packing is the constant study of the growers. The value of brands and trade-marks is receiving due attention from the best planters. The question of varieties and the study of local conditions have been much furthered.

Associations among the fruit growers have been of great advantage, the horticultural society studying production and the exchange concerned in the cooperative marketing of the fruit. Neighborhood associations, too, have helped in studying local questions and also in some instances in the buying of fertilizers, in road building, and in improved shipping facilities.

Agricultural productions are increased with the areas under cultivation. Tree production, other things being equal, increases with the growth of the trees and the consequent extension of the bearing surface. Not only is the productive area enlarged by the extending branches, but the feeding surface of the roots is more extensive than with smaller crops. Porto Rico is destined to be an immense tropical garden—a greenhouse for the eastern seaboard cities of the United States.

INTENSIVE FARMING.

Agriculture in Porto Rico since the American occupation has been pioneering. This has been due to two causes: (1) The change from old to new and improved methods in agricultural practice, and (2) the change from two staple crops to a long list of diversified productions. The change has been retarded by local traditions and by soil depleted by continuous cropping under old wasteful methods.

There is a wide difference here between the production of the best and of the poorer lands. This is shown in values, which vary on a single farm from $20 to $200 per acre. The lowlands are the more valuable and, with the exception of the sandy strip bordering the seashore, are devoted to sugar cane. The mountain lands are devoted to coffee, while the intervening hills are the areas now being planted more to fruit.

It is the fruit grower who has the most difficult problem to face. The foothills have been cropped for many years and have finally been denuded of all forest growth and practically abandoned. As one proceeds toward the Equator it is found that land denuded of trees and cropped for a term of years becomes increasingly unproductive. Whether this is due to the influence of the sun rays, bacteria, or protozoa, it is more difficult to bring the land back to profitable production than in the North. In Porto Rico one of the most serious problems is to restore the deforested foothills to a condition of profitable production.

Fruit growers are doing more than any others to bring this about. They have made great progress, especially on the north side of the island, in improving worn-out land, and they have seen not only their own, but their neighbors', land greatly increased in value through their efforts. Two points are called to their attention: First, they are advised to diversify their efforts and especially to grow more products to improve their living conditions. Even on plantations of great value, if devoted to one main crop, the living conditions of the people dwelling thereon could be greatly improved and a higher standard of living brought about by growing minor crops and live stock that are the accompaniment of even the most humble household in countries where the practice of agriculture has made the greatest advancement. In the second place, the waste places on the farm should be planted. There really need be no waste land in Porto Rico, but all of it may be profitably utilized. The lands are increasing in value at such a rate that their owners can not afford to allow them to remain idle. Many idle areas could be planted to leguminous trees to serve later as shade and windbreaks for fruit, cacao, or coffee.

EXPERIMENT STATION.

The work of the station during the year continued along the well-planned lines previously prescribed. Owing to the many problems and the few workers in the improvement of tropical agriculture, the funds of the station are wholly inadequate to its needs. Equipment needed for further study of fundamental conditions is very necessary for continuing the work. Funds are needed for improving the property of the station and for placing the work in such condition that employees can work to the best advantage for the acquirement of those results that will inure to the benefit of all the people.

REPORT OF THE CHEMIST.

By P. L. Gile.

INTRODUCTION.

The chemical work the past year, as in the previous three years, has been directed chiefly to soil and plant-nutrition investigations. Those investigations begun in the past have been continued, and one or two new problems have been taken up. The importance of restricting the chemical work to these two lines is becoming more evident with the development of more intensive agriculture on the island. It is becoming apparent to the planters that increased production in many cases can come only from an improvement in the methods of soil treatment. The increase in the number of soil samples sent to the station with request for advice as to the proper treatment indicates the extent to which this desire is growing. In many instances this advice can be readily given, in other cases the problems involve questions peculiar to the Tropics that have never been thoroughly investigated. As facilities permit, investigations of the more pressing problems are taken up, but as with most agricultural problems, the solution of soil difficulties is one requiring long-continued investigation. The only way that we may arrive at a more rapid solution of the problems is by increasing the means for experimentation and the number of individual tests.

During the past year progress has been made in this respect. By the cooperation of the planters it has been possible to greatly extend the number of field experiments conducted under the supervision of the station. Some planters are also trying various methods of soil treatment and reporting the results. It has thus been possible to increase the scope of the investigations already under way by increasing the field plats.

There are many soil problems, however, that can not be investigated by field experiments, but must be studied by means of pot experiments. It is important that facilities for pot experiments should be increased in order that this work may be carried on more effectively and conclusions arrived at more rapidly. The laboratory is now fairly well equipped to carry on the work under way and to take care of increased investigations. In the laboratory, however, only one side of the questions can be investigated. With increased equipment for conducting pot experiments the efficiency of the chemical work could be more than doubled and certain elementary and important problems, such as the fertilizing value of our native bat guanos, could be solved in a much shorter period of time. The cost of the increased necessary equipment would be about $3,000. It is hoped that this may be secured as soon as possible.

SUMMARY OF THE WORK.

The analytical work of the past year has consisted in 60 analyses of miscellaneous materials, such as limestone, bones, yams, waters, sugar canes, fertilizers, and bat guanos, and about a hundred complete analyses of soils and plant ashes.

The investigations of previous years that are being continued are on soil disinfection; the availability of nitrogen and phosphoric acid in the native bat guanos; the effect of strongly calcareous soils on the growth and composition of various plants; the action of lime in inducing chlorosis; and the effects of various ratios of lime and magnesia on the growth of plants. Results secured on this latter problem are now being prepared for publication, and further experiments on the subject will be carried on this coming year.

Two new problems have been taken up the past year; one on the best treatment of the red clay soils, the other on the chlorosis of sugar cane. This latter problem is being investigated in cooperation with the Sugar Planters' Station.

THE AVAILABILITY OF THE NITROGEN AND PHOSPHORIC ACID IN BAT GUANOS.

Considerable progress has been made in this subject. In order, however, to bring it to a more rapid completion, the increased facilities for pot experimentation mentioned above are necessary. Samples of bat guanos secured from various caves on the island are subjected to a complete chemical analysis as rapidly as the work permits. Besides determining the amount of plant food in the guanos, the availability of the nitrogen and phosphoric acid are tested by chemical methods. The typical guanos are then tested in pot cultures to determine the immediate availability of these constituents to plants. To determine the more lasting cumulative effect of the bat guano on the fertility of the soil a series of 15 tenth-acre plats has been started at Anasco. A typical bat guano is being tested there in comparison with basic slag.

This work when completed will furnish specific knowledge of the chemical composition and agricultural value of a number of large bat-guano deposits and also such a knowledge of the various types of guanos that when samples are sent in for examination their value can be approximately determined by assigning them to one of the types that has already been thoroughly tested.

By testing the availability of the nitrogen and phosphoric acid as determined by vegetation experiments compared with that determined by chemical methods, a short method may be found for determining the approximate value of these deposits. In the report for 1908, analyses are given of various guanos. Since then samples have been analyzed from time to time for nitrogen and phosphoric acid, and because of the general interest in these deposits the data are here given:

Nitrogen and phosphoric acid in some bat guanos.

Sample No.	Location of deposit.	Nitrogen (N).	Phosphoric acid (P_2O_5).
		Per cent.	*Per cent.*
127	Bayamon		16.18
128	do		8.09
227	Boqueron	0.79	18.60
228	do	.40	24.06
247	Las Marias	3.09	9.44
248	do	3.01	5.31
249	do	.57	10.46
250	do	5.49	4.94
251	do	3.95	4.59

The following guanos have been subjected to a more complete analysis and are being used in pot experiments to determine their availability. The results are calculated on the basis of moisture-free material.

Analyses of bat guanos from various sources.

Composition.	Location of deposit.								
	Aguadilla.	Arecibo.	Las Marias.	Las Marias.	Cabo Rojo.	Cabo Rojo.	Cabo Rojo.	San German.	Vega Baja.
	Lab. No. 263.	Lab. No. 374.	Lab. No. 375.	Lab. No. 376.	Lab. No. 321.	Lab. No. 415	Lab. No. 460.	Lab. No. 458.	Lab. No. 447.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Total nitrogen (N)	0.40	0.52	0.66	3.23	1.63	0.65	0.97	1.32	1.06
Potash (K_2O)	.64	.96	.18	.25		.24	.32	.77	.42
Total phosphoric acid (P_2O_5)	7.77	12.68	18.55	4.35	14.47	20.31	13.56	13.85	26.18
Water soluble (phosphoric acid)	.28	.82	1.10	.46	.53	.41		.51	.33
Citrate soluble (phosphoric acid)	2.64	2.14	2.89	1.96	3.24	1.20	5.85	4.78	10.12
Lime (CaO)	30.49	22.45	13.72	1.74	5.82	14.53	19.86	5.24	32.13
Magnesia (MgO)	Trace.	.20	1.15	.27		.17	.20	.05	.10
Iron oxid and alumina (Fe_2O_3 and Al_2O_3)	3.38	8.71	10.80	12.95	9.07	8.85	8.99	7.22	6.01
Water	2.85	13.82	6.97	13.11	7.20	5.17	21.46	17.01	10.36
Volatile matter	27.65	22.02	28.32	56.67	28.98	17.45	26.34	38.69	19.04
Nonvolatile ash	69.50	77.98	71.68	43.33	71.02	82.55	73.66	61.32	80.96
Carbon dioxid (CO_2)		.57	.00	.00	.00				

It is hoped that good progress will be made in the above work during the coming year, as the question is one of immediate and practical importance on the island. The guano deposits are very numerous, and many are of considerable size. When it is known what quantity should be applied to replace the standard fertilizers and what the monetary value is, a considerable saving can be made in the purchase of commercial fertilizers by using these deposits. Many planters are now utilizing these deposits without knowing how much to apply to replace a given quantity of acid phosphate or sodium nitrate and without knowing whether it pays to use them. The results of the few trials of these materials that have been made by the planters in the past are not very enlightening, as they have used the guanos as complete fertilizers when it can be seen by the above analyses that most of them contain only phosphoric acid in appreciable quantities.

THE EFFECT OF VARIOUS RATIOS OF LIME AND MAGNESIA ON THE GROWTH OF PLANTS.

The results so far secured in the study of this subject are now being prepared for publication; they are, however, in the nature of a report of progress. The conclusions arrived at seem to show the problem to be more complicated than it is generally considered to be. The new phases of the subject that have appeared in the course of the work just completed are being investigated. In the work so far the effect of various ratios of lime and magnesia were tested by growing rice in nutrient solutions, employing the chlorids of calcium and magnesium. The effect of various ratios of lime to magnesia from 10:1 to 1:10 were tried. These ratios were also tried at different concentrations to see if the ratio of lime to magnesia would exert an effect in dilute as well as in concentrated solutions. The experimental results obtained were as follows: In the presence of a small amount of all the other nutrients equal percentage concentrations of calcium chlorid and magnesium chlorid appeared to be equal in their toxic action on rice. When compared on the basis of equivalent molecular quantities, calcium chlorid is more toxic for rice than magnesium chlorid.

In a concentrated solution of calcium chlorid containing a minor quantity of the other nutrients slight increases in the amount of magnesium chlorid greatly improved the growth of rice. A like improvement was produced in concentrated solutions of magnesium chlorid by small additions of calcium chlorid.

In solutions of 164 to 109 parts per 100,000 of the combined chlorids of calcium and magnesium, all the other nutrients being present in minor quantity, the growth of rice was distinctly better where lime and magnesia were present in the ratio 1:1 than in the ratios 10:1, 5:1, 1:5, or 1:10. The favorable action of ratio 1:1 compared with other ratios was more apparent the more concentrated the solutions.

In solutions of 62 to 23 parts per 100,000 of the combined chlorids, all the other nutrients being present, the growth of rice appeared to be unaffected by the ratio of lime to magnesia between ratios of 10:1 and 1:10.

The results of this work differ from similar studies by others on the lime and magnesia ratio in showing that, while the ratio appears to exert an action at comparatively high concentrations, it does not at low concentrations; at least not within the ratios tried. It is possible that at wider ratios than 10:1 and 1:10 an effect might have been observed even at low concentrations. The results show beyond doubt, however, that the effect of the ratio of lime to magnesia is much stronger at high concentrations of these salts than at low ones.

In considering this work together with recent work of other investigators on the toxicity of various salts and the antagonisms existing between them [1] it would appear that the question is not the simple one of a balancing of lime with magnesia, but a balancing of lime or magnesia with all the other nutrients. The facts seem to point to the conclusion that the toxicity of an excess of lime or magnesia is due not simply to an unfavorable ratio between these two salts, but to an unfavorable proportion between the salt that is in excess and all the other salts present.

In applying these results to soil conditions it must be taken into consideration that in ordinary soils the concentration of all the salts is exceedingly low, hence we should not expect the toxic action of any one salt to become apparent unless it were greatly in excess of all the others. In the soil we also have the physical effect of the soil particles diminishing the toxicity of any salt solutions.[2] It would seem, then, that the mere ratio of available lime and magnesia would be without much effect in ordinary soils. But in alkaline soils, where there is a concentrated salt solution, it appears that the ratio of lime to magnesia may be of the utmost importance in determining the growth of plants.

It is not intended to assert the above conclusions too positively, as this action of various salts and ratios of salt upon the growth of plants is a comparatively new object of investigation, and new facts and aspects of the subject are appearing rapidly. The above conclusions are based merely on the facts so far as now known.

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[1] Particularly the work of Loeb, Osterhout, True and Gies, and Lipman on balanced solutions.

[2] G. H. Jensen, Bot. Gaz., 43 (1907), p. 11.

THE EFFECT OF STRONGLY CALCAREOUS SOILS ON GROWTH AND COMPOSITION OF PLANTS.

The work on this subject has been in progress now for two years, and considerable data have been accumulated. It will take probably two years more to complete the work as originally outlined. The object of the investigation is to determine the adaptability of various plants to the limy soils.

This is thought to be one of the more important subjects under investigation. Excess of lime or lack of lime might be called the predominant chemical features of Porto Rican soils. Where there is a lack of lime, acid condition and its secondary effects are encountered; where there is a large amount of lime, many plants suffer from chlorosis. The strongly calcareous soils form a considerable portion of the arable land of the island. On the south and southwest sides of the island, between the mountains and the sea, nearly all the soils contain considerable carbonate of lime, often in an excessive amount, the percentages ranging from 2 per cent to 90 per cent. There are numerous outcroppings of calcareous soils on the north side, and much of the hill land also contains large amounts of lime.

It is well recognized in France and Germany that all crops are not suited to calcareous soils, but the effect of lime on most of the tropical crops is not known. In Porto Rico the limy soils bear a characteristic natural vegetation. It is important to know, however, how the growth of cultivated crops is promoted or depressed by various amounts of lime in the soil. In Bulletin No. 11 of this station it was shown that pineapples are sensitive to carbonate of lime in most soils, comparing with lupines in this respect. In the work carried on so far it appears that the growth of rice is also much depressed by carbonate of lime in the soil.[1] The depression appears to be so large that it probably would not pay to grow rice on most of our calcareous soils.

Some of the other plants tried appear to be unaffected by the carbonate of lime, while others make a better growth on the limy soils. As rapidly as the plants can be grown they are subjected to chemical analysis to determine what effect the lime in the soil has upon the ash content of the plant. It is hoped that this work may show why some plants are adapted to calcareous soils and why others are not.

THE CHLOROSIS OF SUGAR CANE.

This problem, which was taken up the past year, is being studied in conjunction with the pathologist of the Sugar Planters' Station. While this work has, of course, only been started, considerable progress has been made. Most of the bleached or chlorotic patches of cane have been visited and samples of the soil taken, together with samples of the adjacent soil where the cane is green. About 50 of these samples have been analyzed.

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[1] It was also noted in Hawaii that liming rice lands depressed the harvest (see Hawaii Sta. Rpt. 1907, p. 79).

Cane seems to tolerate a considerable amount of calcium carbonate and to do best on soils containing a moderate amount. The best cane soils on the island contain sufficient lime to insure a neutral or slightly alkaline condition. Where the bleached cane has been observed thus far the soil is excessively calcareous.

So far as observed, the white or chlorotic cane seems to be confined to the southern and southwestern portions of the island. It occurs for the most part in patches varying from a tenth of an acre to several acres. In the neighborhood of Santa Ysabel, however, there are several hundred acres which are affected to a greater or less extent.

The soil survey of the chlorotic patches of cane is as yet incomplete, but from the results thus far it seems that the bleached cane is confined to patches of very calcareous soils. The typical chlorosis has not been observed on any soils but those very high in lime, no cases having occurred on the acid red clays. On the other hand, green cane has been observed on patches of soil containing as much carbonate of lime as the soils growing chlorotic cane.

From the similarity of the phenomena with that of the chlorosis of pineapples it was thought that treatment with ferrous sulphate might prove effective in restoring the green chlorophyll to the leaves. Accordingly, the leaves of a few high stools in the midst of a strongly affected patch of cane were brushed with a solution of the iron salt. The result was very striking, as a few days after the treatment the leaves became much greener. These leaves after brushing several times were killed by the solution, but perfectly normal green leaves started out from the top, which were in strong contrast to the white leaves of the surrounding cane. This, of course, was only a small test, but the result was so striking as to indicate that the need of the bleached cane was for iron.

An experiment is now being made in cooperation with the Guanica Central in spraying several good-sized patches of the chlorotic cane. An account will be kept of the cost of the treatment and of the frequency with which the iron solution has to be applied to maintain the normal green.

At Central Cortada a field experiment of some 15 tenth-acre plats is being laid out to find if there is not some way in which the sulphate of iron can be applied to the soil so that it may have a lasting effect. Spraying will also be tried in comparison to see which method of applying the iron is more effective.

THE ACTION OF LIME IN INDUCING CHLOROSIS.

This work is in some respects a continuation of the work published in Bulletin 11 of the station, where it was shown that the chlorosis or bleaching of the pineapples occurring on certain soils was induced by the calcium carbonate of the soil. It appeared in the course of this work that the chlorosis was due to a disturbance in the mineral nutrition of the plant, caused by the large amount of calcium carbonate in the soil. To make sure that this disturbance is the ultimate cause of the chlorosis, other plants that become chlorotic on limy soils are being studied. This work will be largely a correlation of the results secured from individual studies, such as that on pineapples, the one in progress on the chlorosis of sugar cane, and the study of the effect of calcareous soils on the growth and composition of various plants. While considerable progress has already been made on this subject there are many special phases to be investigated that present difficulties in laboratory methods and pot experiments.

ON THE TREATMENT OF THE RED CLAY SOILS.

It has been possible to commence work on this problem the past year through the cooperation of the Guanica Central. This company has kindly placed about 11 acres of land at the disposal of the station and is paying for the labor, fertilizers, and other materials used in the experiments. Thanks are due the company for thus making it possible to undertake this work.

Much of the red-clay soil that has been under continuous cultivation for many years is in what the physiologist terms a "sick" condition, the yield of cane being only 20 to 40 per cent of what should be expected. Applications of various fertilizers that have been made in the past seem to be ineffective in increasing the yield. To just what this nonproductivity is due is as yet uncertain. The investigations of the physiologists seem to point to the cause lying in the bacterial condition of the soil. Some of the red clay soil, however, is still in good condition, responding to fertilizers and yielding good crops of cane.

On account of the two different conditions obtaining on this type of soil the investigation has been divided into two parts. One part of the experiment consists in the investigation of the lime and fertilizer requirements of the soil which is in a productive condition. The experimental field for this purpose is located at Anasco. The other part of the investigation is devoted to the study of what has been termed "sick" soil. The experimental field for this purpose is located at Hormigueros.

For the fertilizer experiments at Anasco 45 tenth-acre plats have been laid out. The effects of the various fertilizing elements are being tested singly and in combination. As this type of soil is almost uniformly acid, improvement is also to be expected from liming. Lime at the rate of 1,500, 2,000, and 4,000 pounds per acre has been applied to some plats, both with and without a complete fertilizer. All the plats are planted to sugar cane.

At Hormigueros, where the soil is out of condition, 42 tenth-acre plats have been laid out. A series of 8 plats which was started in 1909 shows that no improvement is to be hoped for on the land by the application of fertilizer alone. Accordingly, treatments are being tried for bringing the soil into a condition to respond to fertilizers and also to throw light, if possible, on what is the real cause of the low productivity. The following treatments are being tried:

(1) Aeration of the soil by plowing at intervals of a few weeks.
(2) Liming at rates of 2 and 4 tons per acre.
(3) Heavy liming with a subsequent application of barnyard manure.
(4) The plowing under of cowpeas previous to planting the cane.
(5) Disinfection with heavy doses of carbon bisulphid.

The latter treatment is being tried, not as a practical method of treating this soil, but to determine whether or not it is benefited by disinfection. The result of this treatment ought to throw some light on the cause of the trouble. Should the treatment prove beneficial the next problem would be to find a cheap germicide. There are various check plats in the experiment to determine the effect of barnyard manure and complete fertilizer alone as compared with no treatment. It is believed that this problem represents one of the fundamental soil problems in Porto Rico, and it is hoped that the experiments may throw some light on its solution.

REPORT OF THE HORTICULTURIST.

By C. F. Kinman.

CITRUS FRUITS.

The cooperative fertilizer experiments, the study of stocks, bud variation in navel oranges, cover-crop experiments, and variety testing are being continued. Numerous trips have been made to the groves where cooperative experiments are under way for the purpose of applying fertilizers, studying the progress of the plats, and harvesting the crops. A complete record was made of the number of fruits and the weight of the crop from each plat, which shows that the complete fertilizer has given the most profitable return this year. It is hoped that the results of these experiments, which have been conducted since 1906, may be published after this year's crop has been harvested.

In the variety orchard, located on high land, there has been great variation in the growth of the different varieties, but few of them proving to be at all satisfactory. Among the oranges the variety Hart Late has been the most promising. These trees withstand both the long winter drought and summer rainy season and are very prolific and regular in bearing. The fruit ripens in the last part of February or in March, and the crop remains on the trees without deteriorating until late in May. Under local conditions the skins are smooth, thin, and tough, the flesh, while somewhat fibrous, is very juicy, and the flavor very rich. If the fruit is left on the tree too long a greenish color will return.

Among the navel oranges cultivated on the island there is great variation in regard to the quality of the fruit, some trees bearing excellent juicy oranges, while the quality of others is quite the opposite. Evidence has been found to indicate that this difference is in some cases due to bud variation, and that the undesirable trees were propagated from trees with similar faulty characteristics. Material has been collected from different orchards on the island, and experiments to determine the cause of the variation in the quality of the fruit are under way.

PINEAPPLES.

An experiment to determine the practical effect of fumigating pineapple plants before setting to rid them of insects was begun in May, 1909, by the former horticulturist, Dr. M. J. Iorns. Both fumigated and check plats of 17 different varieties of pineapples were set in the

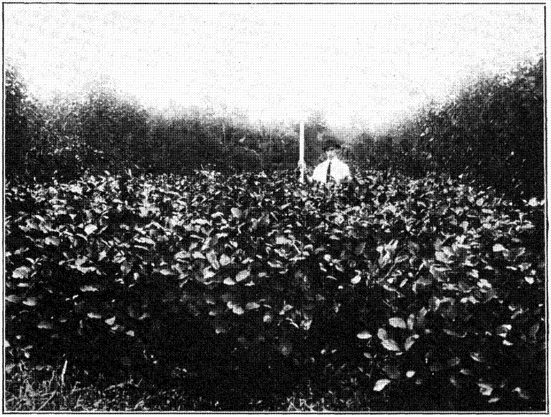

FIG. 1.—THE SWORD BEAN AS A COVER CROP.

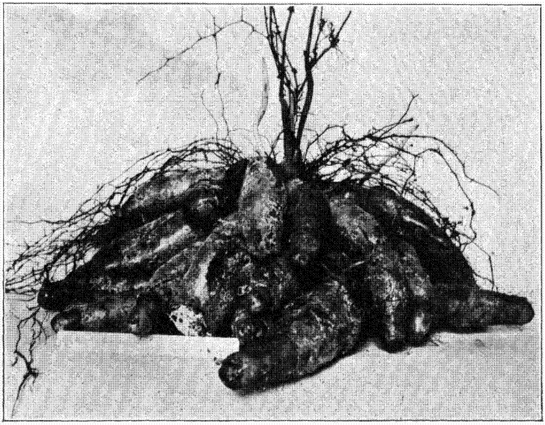

FIG. 2.—THE POTATO YAM.

PLATE II.

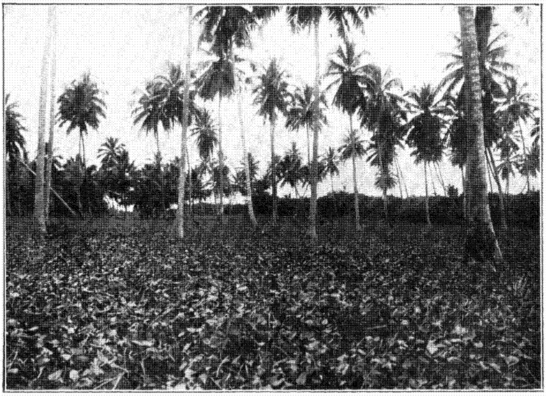

FIG. 1.—COWPEAS AS A COVER CROP FOR COCONUTS.

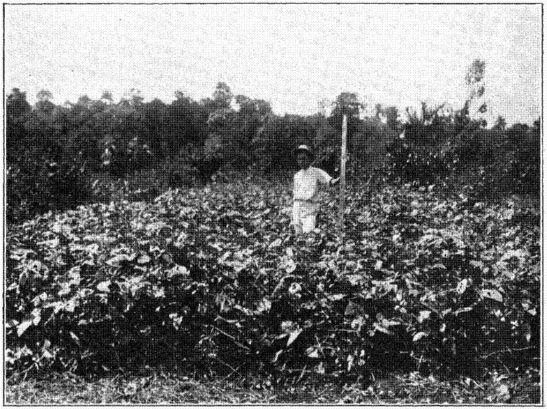

FIG. 2.—VELVET BEANS AS AN ORCHARD COVER CROP.

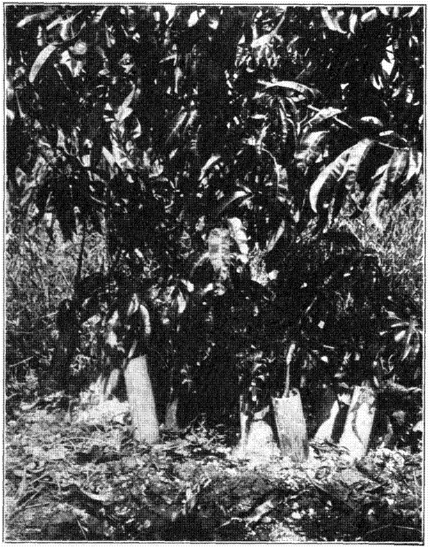

FIG. 1.—INARCHING MANGOES—SEEDLINGS GROWN IN BAMBOO POTS.

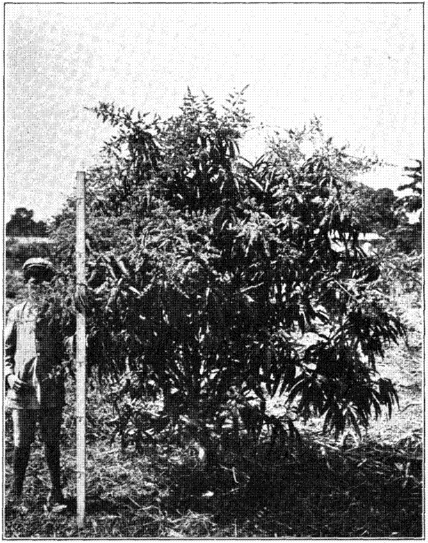

FIG. 2.—MULGOA MANGO IN BLOOM. TREE 3 YEARS OLD.

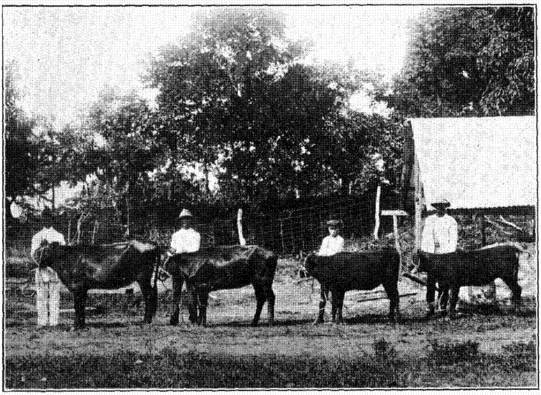

FIG. 1.—SHORTHORN NATIVE HEIFERS.

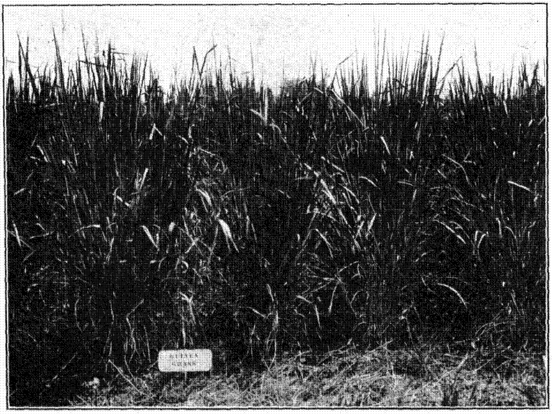

FIG. 2.—GUINEA GRASS GROWN FOR FORAGE.

experiment, and with most varieties large, medium, and small sized plants were used. Owing to the unfavorable weather conditions, the long winter drought, and excessive summer rains these plants have developed slowly, though each variety has produced fruit this year. From time to time during their growth the plants were examined, but no effect on the vigor of the plants resulting from the fumigation was observed, and within a few months after setting insects were found on the fumigated and check plants alike. The mealy bugs are quite active, and they soon went from the check to the fumigated plats and reinfested them.

Young pineapple plants taken from old fields are often badly infested with mealy bugs, and as fumigation strong enough to destroy the insects is not injurious to the plants, it could in many cases be used to advantage. However, as mealy bugs are so well distributed, the fumigation can not be expected to more than assure clean plants for setting, and the customary practices will have to be employed for keeping the plants free from insects after they have been set in the field.

During the latter part of the year plantings have been made to test the effect of leguminous cover crops and tree shade on a number of varieties of pineapples. The varieties Red Spanish and Cabezona were set in cover-crop experiments, and these varieties with a number of others were planted in the shading test. The cover crops planted were the sword bean (*Canavalia ensiformis*) (Pl. I, fig. 1) and pigeon pea (*Cajanus cajan*), or gandules, as they are commonly called here. Pithecolobium trees 7 years old are also being used for shade.

In the variety test field notes on the thriftiness of the plants and quality and quantity of the fruit of the 27 named varieties and of the number of seedlings grown at the station have been taken, and new plantings of each variety have been made for further comparison.

COVER CROPS.

Work with cover crops in citrus orchards reported on last year is still under way and has been taken up in coconut and pineapple plantations. Cowpeas, velvet beans, Canavalia or sword bean, and pigeon peas have given good results (Pl. II, figs. 1 and 2). The cowpea is not so desirable for summer planting on heavy soils as the other crops, as they mature early and often at a time when the soil is too wet for replanting or caring for a new crop properly. The other crops mentioned continue their growth throughout the season of heavy rains and make a dense cover that keeps down all the grass and weeds, and is also excellent for preventing soil washing. The cowpeas have produced good crops of seed when planted in the spring, while the winter-grown crops of the Canavalia and velvet bean are more prolific, as the long winter drought checks the heavy vine growth and stimulates seed production. Also, as the summer rains cause the pods to decay the drier winter months are much more desirable for seed production. The Canavalia and velvet beans planted on low, heavy land April 10 have made an exceedingly good growth, the green weight of the vines 94 days from planting being 12½ tons per acre for the Canavalia and over 9 tons for the velvet bean.

VEGETABLES.

The study of the degenerating influence of Porto Rican conditions on a number of imported vegetable varieties, which was started two years ago, is being continued. Okra, beans, tomatoes, peppers, and lettuce have been grown through a number of generations, and interesting data have been taken. The indications are that at least the okra and beans have degenerated both in vigor of plants and productiveness. This work will be carried on through the fall and winter, and it is hoped that after that time conclusions worthy of publication will be reached.

ROOT CROPS.

Cultural, fertilizer, and variety tests with yautias, dasheens, and yams are still under way and have given good results. Of the 15 varieties of yams the varieties Potato (Pl. I, fig. 2) and Guinea seem the most promising for growing here. These varieties are well adapted to our soil and climatic conditions, producing heavy crops, and the tubers are the most desirable varieties for food that we have tested. Analysis made by the chemical department here shows that the percentage of starch in raw samples of the Potato variety was 23.55 per cent and of the Guinea 24.09 per cent. These varieties are 6 or 7 per cent higher in starch than are other varieties. The variety Potato has been distributed to planters in various parts of the island, while the Guinea has for some time been grown as a favorite variety among the gardeners.

Twenty varieties of sweet potatoes have been imported this year and tested. The summer crop was planted in heavy soil, and the varieties are showing wide differences in growth.

MISCELLANEOUS CROPS.

Strawberries.—The nine varieties of strawberries imported from the United States in November, 1910, bore fruit soon after setting and continued to bear sparingly until the summer rains began. The fruit was of good quality and size, but the crop too small to be profitable. The plants appear to be poorly adapted to the conditions here, as their growth is very slow, and they continue to lose vigor. The varieties Klondike and Aroma seem to be the most hardy.

Eucalyptus.—The difference in vigor in our dozen and a half varieties that are growing in low, heavy land, which during the summer is very wet, continues to increase as the trees grow older. A disease apparently similar to crown-gall has killed a few small trees of different varieties, but the loss has not been sufficient to be considered serious. *E. robusta*, *E. piperita*, and *E. tereticornis* have grown well and are the only varieties that have made satisfactory growth under the field conditions mentioned above. Seedlings of the same varieties as the older plantings are being grown and will be set on high land for comparison with the low-land plantings. The study of soils for seed beds and methods of planting and caring for the seedlings are being carried on, and a large number of seedlings are being grown and distributed to planters over the island.

Bananas.—From the large number of banana varieties that were formerly grown at the station, 25 of the most promising were removed from the high land, where they had been growing, to a lower, more open soil. Each variety has shown a great improvement under the new conditions, though but few of them promise profitable production. Three varieties, which fruited first and which have so far been the most prolific, are the Gigante, Enano, and Manzano. A study of the varieties indicates that there are many duplicates in the station plantings, which would be expected, as the original collections were obtained from many countries and the common names used in the countries from which they were sent were given them here. The variety known in Porto Rico as Gigante appears to be identical with Gigante Guarán and Nada Fahonson imported from other countries, and the Porto Rican variety Enano the same as the imported kinds known elsewhere as Manzano, Cinea India, Apple, and Brazilian.

Mangoes.—The work of extending the planting and distribution of varieties, importing new varieties, studies in propagation, etc., is being continued. (Pl. III.)

The East Indian varieties fruited very poorly this year, the yield amounting to but a small percentage of last year's crop. The varieties Cambodiana, Mulgoba, and Sandershah were not productive this year. The fruit of the variety Cambodiana has in previous years been badly attacked by fruit flies at the time of ripening, but this year the injuries have been successfully prevented by bagging the fruits before they reached full size.

REPORT OF THE ASSISTANT HORTICULTURIST.

By T. B. McClelland.

COFFEE.

The various cultural methods formerly mentioned as being tried on coffee are being continued, and data as to height, number of producing trees, amount of coffee produced, etc., are being collected.

In addition to the old plantings of Porto Rican coffee there are a number of introduced coffees. Of the latter there are something more than 2,500 trees. Among species of coffee other than *Coffea arabica*, in its different varieties, are found *C. liberica, C. laurentii, C. excelsa, C. macrocarpa, C. stenophylla, C. canephora, C. zanguebariæ, C. dewevrei, C. liberica* × *C. arabica* hybrid, *C. mauritiana* × *C. laurina* hybrid, and several coffees of undetermined species.

Among coffees now bearing may be mentioned: Ceylon hybrid; Mocha hybrid; Blue Mountain, of Jamaica; Padang, of Sumatra; Preanger, Pantgoer, Erecta, and Columnaris, of Java; Guadeloupe; Maragogype; Surinam; and Mocha. A number of others should bear their first crop next season.

The coffee trees in the transplanting experiment begun in August, 1909, are now showing some interesting differences. The plants used were seedlings from the 1908 crop. When quite small they were taken from seed boxes and set in the nursery bed.

In transplanting young coffee trees from the nursery bed with only five to six pairs of leaves, careful setting with the root system bare gave as good results as with the root system encased in the surrounding clod. The tendency toward an earlier production was aided either by making the permanent planting when the trees were quite small, that is, less than a year old from seed, or by transplanting with the root system encased in the surrounding clod if the plants were allowed to remain in the nursery bed for a year longer. A more even stand is likely to be secured by allowing plants to remain in the nursery bed a year longer than by transplanting when plants have only five to six pairs of leaves. The cutting back and planting out as stumps of coffee trees less than 2 years old was very unsatisfactory where conditions were not very favorable for coffee culture.

Knowing that coffee seed does not long keep its viability, an experiment was made to see if it might be longer preserved by excluding the moist air of the Tropics. In the autumn of 1909 a number of well-matured coffee cherries were carefully picked, washed, and shade dried for a week, after which they were divided into two portions, of which one was put in a cotton sack allowing free passage of air, the other in tightly closed jars containing under the coffee calcium chlorid as a drier. Every two weeks 100 seeds were planted from each lot. Of those planted up to 10 weeks from time seeds were picked from 94 to 100 per cent germinated. However, after 12 weeks the germination of seeds from the drier was only 27 per cent against a germination of 95 per cent of seed in open air. The last seeds from the drier which germinated, giving 5 per cent germination against 97 per cent for seeds in open air, had been kept 18 weeks. The seed exposed to air fell to 84 per cent germination at 20 weeks, keeping steady until 24 weeks, falling to 48 per cent at 26 weeks, and giving the final germination of 6 per cent at 32 weeks.

In December, 1910, some coffee seed from coffee prepared for distribution was thoroughly mixed and divided into six lots, being treated as follows:

No. 1. Seed in cotton sack in open air.
No. 2. Seed in close jar over water with evaporating surface of cotton cloth.
No. 3. Seed in oven-dried powdered charcoal.
No. 4. Seed in frequently remoistened charcoal.
No. 5. Seed in closed jar over calcium chlorid as drier.
No. 6. Seed in closed jar over concentrated sulphuric acid as drier.

For each test 100 seeds were planted, and two months were allowed for completion of test. A check lot of seeds planted on December 26 gave 92 per cent germination. The results of germination tests as influenced by treatment of the coffee seed are given below.

Germination of coffee treated in different ways.

Seed planted.	Germination.					
	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
1910.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Jan. 26	92	87	94	97	0	97
Feb. 25	80	57	78	86	0	78
Mar. 27	74	39	37	31	0	[1] 45
Apr. 26	49	16	36	([2])	0	0
May 26	21	19	29		0	0
June 26	0	20	1			
July 26	0	11	0			
Aug. 28	0	[3] 24	0			

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[1] On Mar. 27 the contents of a small bottle of sulphuric acid were poured into the bottom of jar containing coffee, giving a larger surface for evaporation of the liquid.

[2] No more planted, as seed were germinating in charcoal.

[3] This is not the ultimate germination from Lot No. 2.

In all these tests the seeds which were very severely dried for any considerable length of time had their viability destroyed, while the checks exposed to the open air and containing more or less moisture still continued to germinate. That the drying must be somewhat severe is shown by the following test made shortly after the completion of the ordinary preparation of coffee for market. One hundred seeds from a pile fermented over night gave a 92 per cent germination. From a lot which had been fermented and the sun drying completed the germination was 71 per cent.

The conclusions from these experiments are that the viability of coffee seed is destroyed by very severe drying and that a certain amount of moisture, as yet undetermined, is necessary for its prolongation.

On the college farm an experiment has been undertaken to find a means of ridding the coffee of the destructive ant, *Myrmelachista ambigua* subsp. *ramulorum*, which infests the guamá (*Inga laurina*). In one section both shade and coffee have been felled, in two others the coffee has been left standing, the shade being felled in one and girdled in the other. Throughout the whole, new shade trees, *Inga vera*, have been planted, and as temporary shade bananas, *Agati grandiflora*, and pigeon peas are being tried. In less than three months after the work was begun, in the section where both coffee and shade were felled, no ants whatever of this species could be seen except on the extreme edges of the plat. From the old coffee stumps strong renewal shoots are being sent up.

On a piece of nearly level land on the station grounds a planting of coffee has been made to test the effects of different fertilizers. It consists of 33 plats of 18 trees each. This will allow one or more duplicates for each test.

VANILLA, RUBBER, AND CACAO.

The vanillas received from the subtropical laboratory at Miami, Fla., in December, 1909, have made a very luxuriant growth. Of these, three Panama vanillas, a *Vanilla eggersii* from southern Florida, and a *Vanilla* sp., "Pompon," from Vera Cruz, blossomed in the spring and summer of the present year. As vanilla is found growing in various parts of the island, it is strange that more attention has not been given it as a commercial proposition. As soon as sufficient cuttings are available more extensive plantings of the commercial varieties will be made to demonstrate the possibilities of vanilla culture under Porto Rican conditions.

A tapping of 15 of the 8 to 9 year old Castilla trees has been made, and the average yield of rubber per tree is but very slightly greater than that of the year preceding.

In 1903 a small wind-protected ravine with sides rather steeply inclined and bottom well watered was set with cacao, most of the plants being from seed brought from Trinidad in March; a few were from seed from trees on the island. The following year a few cacaos were added from the United States Department of Agriculture.

From 272 trees still alive in 1910 the yield for the year ending December, 1910, averaged only about ¼ pound of dry cacao per tree. The conditions under which the trees are growing are at least up to the average for the island. The trees are planted at the rate of about 300 per acre. Cacao sells here at from 9 to 12 cents per pound. This means a gross return of from $6.75 to $9, making no allowance for the eating of ripe pods by rodents, the loss in this way being often very great.

REPORT OF THE ENTOMOLOGIST.

By W. V. Tower.

The fiscal year of 1911 was taken up in studying the white grub in the cane and a coffee ant which infests coffee and practically all its shade trees. Much time was devoted to the station apiary and to giving instruction in apiculture. Studies have been begun on the life histories of the insects affecting the guava, and some important facts have been learned. The station insect collection was greatly increased. Glass-covered mounts were made of many of the injurious insects; also different forms of the various insects were brought together. These were used for the exhibit and also for demonstrating at the insular fair. During March the station was asked by the mayor of San Juan to make a mosquito survey of that city. The writer was detailed by the director to take up this work. It was found that the mosquitoes of San Juan proper were breeding mostly in barrels, cisterns, tin cans, and in standing water. The mangroves around the bay were not breeding mosquitoes, as was supposed. A circular on the survey is now ready for the press. The yellow-fever mosquito was found breeding practically everywhere, as were various forms of Culex.

BEES.

The bee industry in Porto Rico continues to increase. During the past year demonstration classes have been held three times a week and these have been well attended. Most of those who have attended these classes have purchased bees from the station and have started small apiaries. Many of those who studied at the station during 1910 have established commercial apiaries and are now producing honey.

Since taking up this work the writer has studied the flora in practically all districts of the island. Porto Rico is well supplied with honey plants, and it is doubted if there are any localities in which bees would not pay. There are certain districts on the island which are considered especially fine pasturage; they are the foothills in the range of the coffee districts. In Mayaguez, for example, the coffee plantations come down to within about a mile of the sea. Thus, an apiary located near the outer edge of the coffee belt would have two different floras to work upon, i. e., the flowers of the pastures, such as small trees, shrubs, and ground flowers, and the coffee and its shade.

Coffee shade trees produce more honey than the coffee itself. A great number of shade trees are used in coffee plantations which produce nectar. In the lowlands guamá (*Inga laurina*) is used almost entirely, while in the interior the principal shade tree is guava (*Inga vera*). The guamá is by far the best honey plant on the island. This tree blooms from two to five times a year, and the bloom lasts from 10 to 15 days. It is not uncommon for a good, strong hive of bees to gather from 5 to 11 pounds a day. The honey is very light in color and resembles the clover honey of the North. It runs about 12 pounds to the gallon and wholesales in New York at about 85 to 90 cents a gallon.

Bees would probably be beneficial in the orange groves, especially during such seasons as the past, when there was a scarcity of orange bloom. If the planters had had plenty of bees they would undoubtedly have fertilized all the available blossoms, and a far greater crop of fruit would have set. Bees are very fond of the flowers. They gather both honey and pollen, collecting the pollen in large pellets to be used in the hive as food for the young brood. During a heavy flow of orange honey the odor of the plant may be recognized around the hives. Districts in which the cultivated orange is raised would probably not afford as good pastures as the coffee, but bees would be able to store sufficient honey so that they would not have to be fed. If feeding was necessary, the small amount of honey used by them would be repaid to the grower by the increase of his crop.

No bee disease has been observed, nor has any been reported to the station during the past year. A circular on beekeeping was published in English and Spanish.[1] This circular discusses the various appliances used in beekeeping, methods for manipulating bees, and a list of the more important honey plants on the island. The circular also takes up the question of the possibility of introducing bee diseases into the island. All beekeepers should realize the importance of keeping out bee diseases. In countries where foul brood has become established, it causes great losses every year. This disease is especially destructive in tropical countries, and it should be the aim of every beekeeper on the island to investigate the origin of all importations of bees, reporting the same to the experiment station at Mayaguez, or to the board of commissioners of agriculture at San Juan. The law prohibits the importation of bees in hives or nuclei, but it provides for the introduction of queens in mailing cages. Although the law is somewhat strict, it seems best to have it so, considering the importance of keeping out this dreaded disease—foul brood.

The station has had a great many inquiries as to how much honey a good colony would produce in a year. As no figures were available, two colonies were placed on a pair of scales and their weights taken morning and evening. Although the number of colonies was limited to two, some very valuable data were obtained. The readings showed at what seasons the bees were most active; also what flowers produced the greatest quantity of honey. During a period of nine months from one of the colonies there were extracted 470 pounds of honey, while the other produced 337 pounds. The only period when both colonies were not gathering was during September, and during this month the small colony gathered sufficient honey so that it did not have to use any of its surplus. Beginning the latter part of February and through March, April, and May, the bees worked on the general bloom, and it was not uncommon for them to gather from 1 to 2 pounds of honey per day. July and August were good honey months; during these two months one of the hives gathered 203 pounds of honey.

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[1] Porto Rico Sta. Circ. 13.

CITRUS-FRUIT PESTS.

The citrus fruit for 1911 was much freer from scale, russets, and scars than formerly, as the windbreaks are developing and giving the trees more protection. The beneficial fungi are holding the various scale insects in check, and in some groves the planters have not had to spray for scale for the past two crops. Scarred fruit is not as prevalent because the windbreaks keep out the wind and there is not so much rubbing, which eventually produces a scar. Many of the growers are using sulphur sprays for the rust mite, and there is a marked falling off of the percentage of rusty fruit. Bamboo continues to be the favorite windbreak; it is quick growing and gives protection in two years. The mango is also being planted, but it is much slower in developing. The one objection to both of these is that they are gross feeders. A ditch should be cut alongside of the plants to prevent their roots from extending out into the groves.

MANGO INSECTS.

The mango is one of the most productive fruits of the Tropics. It has many enemies, but, as practically no mangoes have been raised on the island for shipment, the planters have not become interested in their injurious insects. During the past few years, the experiment station at Mayaguez has imported choice varieties from India, the East Indies, and from the other West Indies. Some of these have borne fruit, and it was found that some of them were infested with fruit flies. Upon this discovery a preliminary study was made of the insects affecting the mature mango. The native mangoes, with one exception, are comparatively free from insects. The worst pest is a fruit fly (*Anastrepha acidusa*)[1]. It does not attack all varieties of mangoes, but is very partial to the Cambodiana, and it practically ruins this variety. It is almost impossible to find a ripe fruit which does not contain at least from two to five maggots. From some fruits from 20 to 25 flies have been raised. The adult fly is very similar to the fruit fly of the guava, and it may be the same species. The life history of this insect has not been completely worked out. The adult female lays her eggs in the green fruit. All sizes of fruit are infested, from those the size of large walnuts to those as large as hen eggs. The larva is a soft-headed worm, and it feeds on the fleshy part of the fruit. Some mangoes have been found containing larvæ in such numbers that the whole inside of the fruit was eaten, leaving only the skin, a mass of fibers, and the seed. Young mangoes badly infested drop to the ground long before they become full grown.

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[1] Determined by W. R. Walton, Bureau of Entomology, U. S. Department of Agriculture.

The mature larvæ bore through the skin and pass into the ground to a depth of about 1 to 1½ inches; there they pupate in about 24 hours. The immature larvæ are flesh colored, while the mature larvæ are yellowish. The newly formed pupa is yellow, but gradually turns to a deep reddish brown. The pupal period lasts from 13 to 16 days. The adult fly is about the same size as the common house fly. They are beautifully marked, the predominating color being yellow. The wings are transparent and marked with black.

No experiments on the control of this insect on the mango have been undertaken by the station, but in other countries considerable work has been done on other species of fruit flies. Poisoned sprays and baits are being used; also some beneficial parasites have been found.

A number of scale insects are found on the mango. A small white scale ("Indica") is found on the trunks and large branches. This scale is a pest in India, but in Porto Rico it does not seem to spread rapidly. On some of the trees at Mayaguez this scale has been found parasitized by two species of beneficial fungi; one, the common black species, occurring on the white scale of the orange, and a brown fungus, which is found on the purple scale in the mountains. These two fungi, it is hoped, will exterminate or hold this scale in check. It is believed that these fungi will not be effective in checking the scale on mango trees that are isolated from other trees, any more than do beneficial fungi check the various scales in orange groves where the trees are not protected from the wind. Windbreaks will be beneficial in controlling the soft lecanium, wax, orange, red, and small star scales. All these scales are found on the mango, but are held in check by parasitic fungi only when favorable conditions exist, such as protection from the wind and an excess of moisture. All the mango scale insects are found on the trunks, branches, and leaves, and not on the fruit.

Sooty mold is a fungus which obtains its nourishment from honeydew secreted by the lecanium scale, giving the trees an appearance of being covered with charcoal dust. Thrips are rather plentiful on some varieties of mangoes, especially those that are infested with the fruit fly. These insects are very small, almost microscopic. They obtain their nourishment from the leaves and unripe fruits through a minute proboscis. This insect passes its pupal stage in the ground, and in California it has been found that clean culture and frequent cultivation under infested trees during the pupal period is beneficial. Emulsions of kerosene and whale-oil soap are also successfully used as sprays in killing this insect.

REPORT OF THE PATHOLOGIST.

By G. L. Fawcett.

PLANT DISEASES.

Coffee.—More time has been given to coffee diseases than to other subjects. In the work with the root diseases several new methods for preventing the trouble, were tried, but it is yet too early to get definite results from these experiments. The diseases of the fruit, which make the preparation of the grain more difficult by causing the flesh to adhere, and which, by spotting the grain, lower the quality of the product, have been studied and found to be due in part to improper shading and soil conditions. As the leaf rot spreads most rapidly at the time of the heavier rains, and its rapidly growing mycelium is especially sensitive at this time, it is important that sprays applied during this season should adhere well. For this purpose various adhesives were added to the Bordeaux mixture, among others the borax-starch mixture, which has been strongly recommended for use in cacao plantations in regions of heavy rainfall. Ordinary Bordeaux mixture made up with but half the usual amount of water without the addition of adhesives was found to adhere better than Bordeaux of the usual dilution mixed with any of those adhesives tried. It was necessary to discontinue the work with the West Indian coffee diseases until a more suitable place can be secured.

Coconuts.—A "bud rot" of the coconut has been found at various points along the western coast, as mentioned in previous reports, and probably it occurs in other parts of the island. It destroys some trees each year in many of the plantations, but the number of trees so lost seems to be comparatively small. There can be no doubt that some of the trees apparently suffering from this bud rot have been really injured by lightning. In every case studied bacteria have been isolated from the innermost diseased tissue, but uniformity in the results of such studies has not been obtained. In connection with this work other interesting though minor diseases of this plant were noticed.

SOIL BIOLOGY.

Some work with the bacteriology of "sick" soils was done on lines suggested by Dr. Oscar Loew. The only result of interest from this work was in finding in two of the worst soils a complete absence of protozoa. The soils were taken from near the roots of a coffee tree which had recently died from the effects of unfavorable soil conditions and from one of the worst parts of a field of diseased cane in the San German Valley. A small area of each soil was disinfected by a heavy application of carbon bisulphid and samples taken from soil so treated and from the surrounding undisinfected soil. The samples of disinfected soil were taken about 6 inches below the surface and at a distance of 18 inches from the point where the application of the disinfectant had been made seven days previously. None of the cultures from these soils, either disinfected or nondisinfected, gave any growth of protozoa, although kept several weeks. Bacteria were abundant in the cultures of both soils. It is at least clear that any good results to be derived from the disinfection of these soils can not be due to the destruction of the protozoa, yet canes planted in boxes of the disinfected soil gave a much more vigorous growth than those planted in soil not disinfected.

A STUDY OF ROYAL-PALM ROOT NODULES.

It is well known that several nonleguminous plants harbor in their roots fungi which are probably beneficial in some way, such as rendering it possible for the plants to secure a larger supply of nitrogenous food. Of these plants *Podocarpus chinensis*, which bears fungus-inhabited nodules, has been grown for several years with no other source of nitrogen than that to be derived from the air.[1] Almost equally good evidence of ability to draw on the air as a source of nitrogen has been found for others of these plants, such evidence being based on ability to grow in nitrogen-free solutions or the proof of the presence of proteolytic enzyms in the nodules and the partially digested appearance of the contents of nodules when examined with the microscope.

In the root nodules of the royal palm of Porto Rico is found a fungus which resembles in some respects that described from the nodules of Podocarpus. This suggests that this palm also might be able to secure part of its nitrogen from the air. To test this point palms are being grown in clean sand and watered with a nitrogen-free solution and others with a complete nutritive solution.

Plants grown from disinfected seed in sterilized soil developed nodules which contained no fungus. On the roots of plants growing wild very young nodules are to be found in which there is no fungus, but these plants contain what is apparently the same fungus in all the older and most of the young nodules. The presence of the fungus is accompanied except in the youngest nodules with a rich development of proteids. The fungus-free nodules contain no stored-up starchy or nitrogenous food material. The material in these richly stored older nodules can well be absorbed by the tree to judge from the number of flaccid or empty nodules with still sound exteriors and the partly decomposed conditions sometimes to be observed in the older nodules when examined microscopically. Tests for proteolytic enzyms in the nodules have not yet been made. Since nodules are formed without the fungus, the real problem in growing in nitrogen-free cultures is to test the comparative ability of plants with fungus-bearing nodules and those with nodules lacking the fungus to thrive under such conditions.

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[1] Nobbe and Hiltner, Landw. Vers. Stat., 51 (1899), p. 241.

The royal palm and some other palms have "air roots" which are developed in abundance from roots which would otherwise have no connection with the air owing to being covered by thick, close, or water-saturated soils. Such roots are characterized at first by a somewhat swollen appearance not unlike that of the nodules. Later the epidermis breaks away and the underlying cells expand into a white spongy mass. This same spongy tissue is developed in older fungus-free nodules. The chief difference between the nodules and the root structures which clearly serve no other purpose than to aid the "breathing" of the roots is in size, the nodules being but 2 to 4 millimeters long, the corresponding part of the air roots reaching a size of 1 to 2 centimeters. The nodules are usually formed in loose soils or on roots growing along the surface of the soil beneath decaying vegetation. It would seem that the nodules are possibly air roots which possess the additional function of assisting the palm to secure a larger supply of nitrogenous food material.

REPORT OF THE ANIMAL HUSBANDMAN.

By E. G. Ritzman.

The work in animal husbandry has been materially broadened during the past fiscal year. One of the chief lines now in progress is experimentation in animal breeding and acclimatization. Owing to lack of pasture lands and also to the unfavorable location of the station for stock breeding, a part of this work is being done in cooperation with breeders situated in more suitable localities. Some stimulus has been given to the stock industry by the insular fair held at San Juan during the month of February. This fair is of special interest in relation to the station work, as it is an agency to help promote interest in live-stock improvement. Nearly all the live-stock exhibits at the fair were importations from the States, but it is expected that the next fair will be more largely composed of native-grown or at least locally owned stock. Considerable interest was manifested in the splendid exhibit of chickens brought to the fair from the States which, when sold at public auction, brought exceptionally high prices. Horses also commanded considerable attention, and the prices obtained for them show that good light-harness horses are in demand. Cattle of beef type, including Herefords and Shorthorns, brought low prices at public auction. These sales reflect in a large measure the general attitude existing here toward foreign stock.

The station had a very creditable exhibit which attracted considerable attention and received favorable comment. It consisted of four bulls—Jersey, Guernsey, Shorthorn, and crossbred Zebu; Berkshire pigs; and poultry, including barred Plymouth Rock and White Leghorn chickens, White Pekin and Indian Runner ducks, Bronze turkeys, Toulouse geese, and Homer pigeons.

HORSES.

During the first part of the year the horses purchased in the States the year preceding were sent to various parts of the island, the older ones for stud purposes and the younger ones to localities more favorable for growing stock. They are all doing well and keep in good condition. One colt which had developed an acute case of osteoporosis here in Mayaguez was almost entirely cured after six months on the south side of the island.

Of the first lot of colts sired by the oldest horse 26 have already been foaled. These colts are much larger than pure native stock.

Some are from mares which are crossbred from native mares and American saddle-bred stallions. They are, therefore, three-quarters American saddle bred and should make a valuable improvement both in size, conformation, and color, but are as yet too young to give any definite indication of future development. A few mares have also been bred to the thoroughbred stallions during the year. These thoroughbred stallions are undoubtedly more closely related to native stock, but are much larger than the latter. They should, therefore, nick well, add considerable size, and preserve in the progeny the stamina and vigor which are notable characteristics of the breed.

CATTLE.

Cattle for strictly beef purposes are little in demand, and it is doubtful if such will attain popularity until the ox is replaced for working purpôses. The available pasture lands are now hardly sufficient for the production of draft oxen and dairy stock, both of which are at present greater economic factors than beef cattle, inasmuch as these two classes of stock supply the demand for beef when they have become useless for work or milk production.

Methods of cultivation, class of labor, and the unsuitability of the larger draft horses to this climate, make the work ox necessary, at least for the present. The work begun last year in cooperation with cattle breeders on the south side of the island to produce a work ox which is larger, more active, and more resistant to ticks is now beginning to give results. Nearly 70 calves have already been sired by these crossbred Zebu with Shorthorn and Zebu with Hereford bulls. These bulls are now 3 years old, large, strong, very active, and possess superior qualities for beef as well as for work. Their tick-resisting qualities have been demonstrated, and their condition during the last drought was in favorable contrast to that of the cattle grazing in the same field. The calves sired by them are considerably larger than native calves and promise to develop more size. There is a strong demand from breeders of work oxen for the service of these animals.

There is always a great need for dairy cows that yield a fair quantity of milk. It appears to be the general experience that dairy cows brought from the States will not yield as large a quantity of milk in Porto Rico. This fact, together with some danger in their introduction, makes dairymen somewhat reluctant to introduce pure dairy cows which would otherwise find ready sale. In continuation of the work to improve dairy stock the station keeps three pure-bred bulls, Guernsey, Jersey, and Shorthorn. The service of these animals is much in demand and will no doubt add materially to the improvement of this class of stock. The two former were brought from the States during this year, and the latter was calved here from pure-bred parentage. The station also has four crossbred Shorthorn native females bred at the station (Pl. IV, fig. 1) and one crossbred Hereford native cow. Although they are very pretty individuals, yet it is doubtful if crosses from beef breeds and native stock have any great economic advantage over selected native stock, as they are inferior for work and, with the possible exception of the Shorthorn cross, they are no improvement for dairy purposes. One breeder who has tried Herefords in the better grazing section states that they are absolutely unsuited to that section.

SHEEP.

There has been a limited demand for the African woolless sheep introduced during the previous year. Although they keep in fair health in this locality, yet they fail to put on flesh. On the other hand, sheep of this breed sent to the south side of the island, which is drier and more suitable for sheep raising, have done well. They keep in excellent condition on inferior pasturage and show considerable mutton tendencies. In addition to this they mature early, possess extraordinary fecundity, and have two lambing seasons a year.

The Southdown ram introduced during the year has been mated with native and African woolless sheep. Lambs dropped by the latter show dominance of the African sheep in color transmission and of the Southdown in wool development. Nothing can as yet be said regarding any improvement of mutton qualities. Even under the unfavorable conditions existing in this locality for sheep breeding this Southdown ram has kept in good health since his arrival, and that such sheep can be safely introduced into the drier sections of the island is beyond question.

PIGS.

A considerable number of Berkshire pigs, bred at the station, have been sold during the year as foundation stock to breeders. The demand for such stock is steady, and favorable reports have been received from many who have tried them.

A number of Poland-China, Duroc-Jersey, Hampshire, and Tamworth pigs brought from the States for exhibition at the insular fair were sold here for breeding purposes. Very favorable reports have so far been received of the Hampshires and Tamworths.

An interest in pure-bred pigs is gradually developing. Their rapid growth has made them a profitable side issue in the neighborhood of towns where kitchen offal can be obtained at a very low cost from hotels. Although the cost of corn and other pig feeds, such as ship stuff and slaughterhouse by-products, would make pig raising prohibitive if depended on solely, yet there is considerable profit in the utilization of kitchen waste where it can be obtained steadily, supplemented by forage crops, palm seeds, etc., and to a limited extent by mill and slaughterhouse waste.

POULTRY.

The poultry stock has received an addition of Indian Runner ducks during the year. The interest in various breeds of poultry, especially chickens, is steadily increasing, as is shown by the sale of birds and eggs for breeding purposes. The year's sales included 50 chickens, 24 ducks, 4 geese, 12 Homer pigeons, and 150 settings (1 dozen each) of eggs. The effect of such sales is already very noticeable throughout the island. Pure-bred birds or crosses from Plymouth Rocks can now be seen in almost every locality. The correspondence concerning requests for information on care and treatment of poultry is also growing.

DAIRYING.

A dairy has been begun, and the milk is handled under as sanitary conditions as the limited laboratory appliances now available will permit. The chief object so far has been to demonstrate methods of handling milk in a more sanitary manner than is now generally done. There has been great demand for the milk so handled. Some butter was also manufactured, and it was found that butter can be made which is of good quality when milk can be properly handled in cold storage.

Dairy conditions on the island have received a decided impetus by the organization of a dairy company in Ponce. This company has erected a large modern factory, with equipment of the most improved type, and milk is handled under sanitary conditions from the time it is milked until it reaches the consumers. A good quality of butter is also manufactured by them, and depots are located in the principal cities of the island where these products are retailed at a moderate price.

STOCK FEEDS AND FORAGE CROPS.

Stock feeds and forage crops still maintain a standard of prices which acts as a great drawback to a greater development of the live-stock industry. The number of stock kept on the island is about the maximum which present conditions of feeding and feed production will maintain. That a much greater number of stock could be maintained and brought through the whole year in better shape by the adoption of a system of forage production is beyond doubt.

The work of making and feeding silage at the station has been continued. The result of three years' investigation indicates that the production of good silage offers fewer obstacles than in colder climates, and, further, that native stock as well as imported stock will eat it readily. At the station corn, whole cane, cane tops, and malojilla or Para grass have all given satisfactory results for silage. Para grass is difficult to bring through in good condition, as it is very light and does not settle or pack sufficiently unless heavily ballasted. After two failures to make good silage from Para grass another attempt was made in which the grass was covered by about 6 feet of cut corn for ballast. This kept in perfect condition, and there was only a very small percentage of loss. Corn silage is most readily eaten, but the results of feeding experiments show that when properly made and fed cattle will eat cane tops also. This would mean a great saving of feed, a large part of which is generally regarded as waste, and would help cane planters to bring their working oxen through in better shape and on less acreage.

Some preliminary investigations in the production of forage crops which are especially suited to dry seasons and hill regions have been begun (Pl. IV, fig. 2). A few grasses and a number of sorghums have been planted so far. One of these sorghums, introduced from Barbados, promises to be an especially valuable crop. Small plats grown during the dry season gave a yield of 20 tons of forage per acre with a heavy yield of seed, and when grown during the wet season it gave 50 tons of forage but did not develop seed. If cut constantly before it blossoms it is perennial in habit. Sword beans and cowpeas also grow luxuriantly with sufficient moisture. Rape thrives well in suitable soil and makes a valuable feed, as it requires little cultivation. Of the grasses tried during the last year *Paspalum dilatatum* appears to be a valuable addition to withstand long droughts, but it requires a well-cleaned soil for a start, else native grasses and weeds will choke it out. Rhodes grass is also being grown, but has not yet been tried on a large area and left to contend with other grasses.

MINERAL NUTRITION.

The investigations begun last year in mineral nutrition with pigs have been concluded and the results compiled for publication. These results indicate that calcium chlorid can be used profitably as a supplement to bone meal in rations deficient in calcium. The results further point to the fact that mill feeds, such as middlings and shorts, which are notably poor in calcium, are, on the other hand, too high in magnesium unless supplemented by a sufficient amount of calcium. A study of the relationship between calcium and magnesium and their effect on digestion and assimilation shows that an excess of magnesium retards assimilation and increases the cost of growth unless there is present a sufficient amount of calcium to neutralize the effect of the magnesium surplus. Comparisons of calcium chlorid with tricalcium phosphate (bone meal) show that there is only a small variation among individual pigs in utilization of calcium chlorid, whereas there is a wide difference among individual pigs as regards utilization of bone meal.

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PORTO RICO AGRICULTURAL EXPERIMENT STATION,

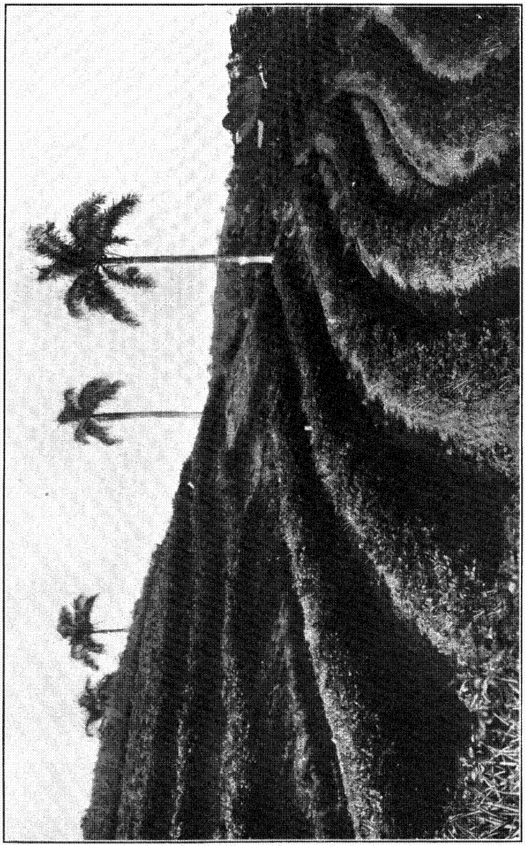
D. W. MAY, Special Agent in Charge.

ANNUAL REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION FOR 1912.

UNDER THE SUPERVISION OF
OFFICE OF EXPERIMENT STATIONS,
U. S. DEPARTMENT OF AGRICULTURE.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1913.

An. Rpt. Porto Rico Agr. Expt. Station, 1912. FRONTISPIECE.



SWORD BEANS GROWN ON TERRACES TO PREVENT EROSION AND ENRICH THE SOIL.

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PORTO RICO AGRICULTURAL EXPERIMENT STATION.

[Under the supervision of A. C. TRUE, Director of the Office of Experiment Stations, United States Department of Agriculture.]

WALTER H. EVANS, *Chief of Division of Insular Stations, Office of Experiment Stations.*

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LETTER OF TRANSMITTAL.

Porto Rico Agricultural Experiment Station,
Mayaguez, P. R., November 1, 1912.

Sir: I have the honor to transmit herewith and to recommend for publication the Annual Report of the Porto Rico Agricultural Experiment Station for the fiscal year ended June 30, 1912.

Respectfully,

D. W. May,
Special Agent in Charge.

Dr. A. C. True,
Director, Office of Experiment Stations,
United States Department of Agriculture,
Washington, D. C.

Publication recommended.
A. C. True, *Director.*

Publication authorized.
D. F. Houston,
Secretary of Agriculture.

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ANNUAL REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION FOR 1912.

SUMMARY OF INVESTIGATIONS.

By D. W. MAY, *Special Agent in Charge.*

INTRODUCTION.

Porto Rico has had another prosperous year. Her exports, nearly all agricultural products, exceed those of the previous year by $10,000,000, amounting to $49,705,413, a sum larger than ever known before in the island's history.

While sugar still leads, the striking feature of production is new and diversified crops. The fruit industry, from a beginning dating only a few years ago, amounted to over $2,000,000. Coffee that had languished since the American occupation is gaining not only in price but in production.

With the great increase in production in Porto Rico, the trade of the island increasing fivefold since 1901, the possibilities have by no means reached a limit. There is not only much land yet not cultivated, but the intensive cultivation of the soil is only beginning and is to no extent as yet a matter of common practice.

While the insect and fungus troubles of plants in the Tropics are multiplied, the yields where these are successfully combated and good cultivation practiced are enormously increased over those obtained in more temperate zones. Less land but more intensive cultivation should be the practice in tropical agriculture. One great mistake usually made by planters from the North is the attempt to cultivate too much land. Where there is a growing season of 12 months it is easily apparent that it will cost more to cultivate than where frost puts the land out of cultivation and keeps it clean for 4 or 5 months of the year.

LINES OF WORK.

The station work has naturally drifted toward specialization, with basic principles in view. Tropical agriculture presents different characteristics from those in the Temperate Zone and this in turn is caused by differences in soil as well as climate. Special attention, therefore, has been directed toward the study of the soil, its chemical composition, and the bacterial and animal life inhabiting it.

Tropical soils are often thought of as covered with dense vegetation. This is usually the case under natural conditions, but the most fertile may become sterile and unproductive by the improvident hand of man. Fertile land in the Tropics covered with a heavy growth of timber, when denuded becomes poor and unproductive, producing only scant grasses and brush. Besides the washing, the humus of these soils is soon destroyed by the scorching rays of the tropical sun, and the favorable bacteria under such conditions disappear or are greatly reduced in number.

One of the greatest problems in Porto Rico is that of bringing such lands again into profitable production. Fertilizers for this purpose are costly and the betterment caused by their application at best is only temporary. A more reasonable method appears to be by growing legumes on the land. Nitrogen in most cases is, after all, the limiting factor in agricultural production in Porto Rico. While it is the most expensive element in fertilizers, it is the one most easily available to our lands. From the immense stores in the air overlying the fields nitrogen can be drawn through the large number of legumes well suited to the soils and climate.

Cowpeas mature in 70 days and will grow in most sections throughout the year. The sword bean (*Canavalia* sp.) is very hardy and suitable under most adverse conditions (see frontispiece). *Dolichos lablab* grows wild and produces forage while storing nitrogen in the soil. The gandul or pigeon pea follows man around the tropical belt of the world and the humblest homes are surrounded by them, affording food while enriching the soil. Many trees, too, are available for reclaiming waste or unproductive land. The gallito (*Agati grandiflora*), of India is one of the best temporary trees for this purpose. It is a wonderful collector of nitrogen as are some native trees, such as the bucare (*Erythrina* sp.), guamá (*Inga laurina*), guava (*Inga vera*), and moca (*Andira inermis*).

It is the policy of the station to promote by every means possible the planting of legumes. By advice, by precept, by example, by the free distribution of seeds and plants, this has been urged. The lands of Porto Rico are becoming more and more valuable, and they should not remain idle and unproductive. The planting of a legume makes possible the production of a more valuable crop. The coffee industry has survived without rotation not because of the shade, to which it is ascribed, but because of the fact that without exception the shade trees are legumes and are continually putting into the soil the essential nitrogen needed by the recurring crops of coffee.

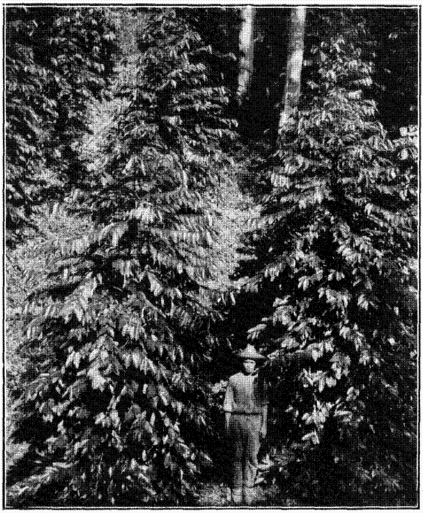

FIG. 1.—COLUMNARIS COFFEE TREES, THREE YEARS FROM SEED BED.

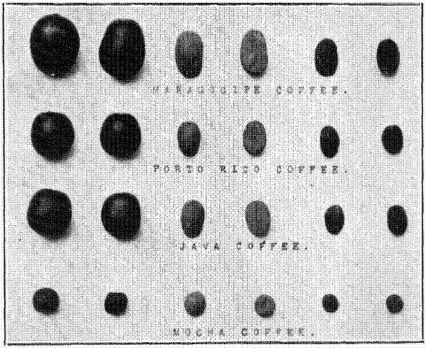

FIG. 2.—SOME TYPES OF COFFEE GROWN AT STATION, SHOWING BERRIES, COFFEE IN PARCHMENT, AND GRAIN.

Fruit growers, too, need to plant more legumes not alone for windbreaks but for nitrogen. It is not necessary for them to buy this element when needed amounts can be so easily secured through leguminous trees used for windbreaks and the beans and peas which are so well adapted to cover crops.

COFFEE.

There has been no recent extension in the planting of coffee. There is, however, pronounced improvement in the cultivation and resulting yield. Prices also are better, owing partly to the production of a better bean but especially to the increase in price of all coffees in the world's markets. There is not likely to be a greater area planted to coffee in Porto Rico. Owing to improved trade relations, rock roads and better shipping service, the island is rapidly falling within the area where perishable products may be quickly and cheaply placed in the best markets of the world—the areas of large population in the United States. Coffee being a compact, nonperishable product, lends itself readily to outlying lands and inaccessible areas of the Tropics. In Porto Rico there is a movement toward diversified agriculture in the mountain lands, and coffee, the former king, is giving way to fruits.

There is, however, considerable land in Porto Rico somewhat inaccessible that can be profitably devoted to coffee. The station is growing coffees from different countries of the world, some of which have been bred up to higher yields of excellent beans. (Plate I.) Seeds of these are distributed annually without cost and planters are urged to try them as well as to carry on a system of careful selection of their own trees for planting. Porto Rican coffee is well relished and sells for high prices in certain markets. That the yields are low is due in great measure to the fact that seed selection has not been practiced, but on the contrary groves are set of volunteer trees that have sprung up under the old trees from shattered coffee, in many cases from immature or diseased beans.

Instances are multiplying where old run-down coffee plantations have been put upon a paying basis by improved cultivation and diversification.

The fruit industry in Porto Rico has made a great gain during the year, exports amounting to over $2,000,000. Porto Rican fruits, although new in the mainland markets, have already won a high place. Grapefruit especially has already become noted, and sales in the open market have reached $12 per box.

In matters of production the fruit growers of to-day have a marked advantage over those of a few years ago, when this industry was in the pioneer stage. Problems have been solved that go a long way toward eliminating the question of chance. Fruit soils and the proper location and protection of groves are better determined. While there will always be a large element of chance in fruit production, yet many of the mistakes in the beginning of the industry in the island may now be avoided. With continued perseverance and intelligence applied to the business, fruit growing is destined to become the premier industry of Porto Rico.

TOBACCO.

The tobacco lands of Porto Rico where the best qualities can be grown are somewhat limited in extent. While the acreage does not show a large increase from year to year, there is, on the other hand, a distinct betterment of the quality. The manufacturing of cigars and cigarettes has shown the greatest increase, and Porto Rican cigars may now be found in all sections of the United States, where a few years ago they were unknown.

The Porto Rican American Tobacco Co. has established an experiment station at Caguas, P. R., in the heart of the tobacco industry, which has materially helped in improving the yield and the quality of our tobaccos.

SUGAR CANE.

In annual production sugar cane still leads in value over all other crops. The area that can be profitably planted to this crop has been planted about up to the limit. All the coast lands have been planted and the cane extended into the hills until losses have occurred to stop the advance. Even the coast lands in some cases, because of repeated harvests, are becoming unprofitable. They do not always respond to fertilizers, and, having become infested with cane diseases, the only recourse left to the planter is to rotate them.

The cane growers have wisely established an experiment station to study the various questions relating to their industry. This station is therefore devoting less especial attention to this crop than formerly. Such experiments as are conducted are mainly along the line of rotations for this crop. Some work in cane breeding and the introduction of new varieties from other countries is being continued.

FARM ENGINEERING.

During the year many improvements have been made in the station property. These have been of a permanent nature. In the Tropics even the best of wood is very perishable. The damp nights followed by hot days soon cause rot, and, besides, certain insects, as the white ant, soon destroy wood protected from the elements. In all station work cement is used wherever possible.

The wooden culverts on the farm have been replaced with cement. Cement fence posts are replacing the wooden ones as rapidly as they can be made. A cement tunnel has been constructed from the cistern where the tile empty, direct to the river. This obviates the continual cleaning of a large surface ditch and carries off the water more quickly after heavy rains.

A machine for making cement tile has been purchased and the tile are now under trial compared with clay tile. Where the cost of wood for burning is as high as it is in Porto Rico, cement tile can be made at a less cost than clay tile.

Cement blocks, both hollow and solid, have been used during the year in constructing several small houses. Molds were made of 1-inch boards 6 by 8 by 18 inches and without top and bottom. These were fastened together at the corners with wooden pins so that they could be easily taken apart. In them was placed a mixture of cement, sand, and gravel in the proportions of 1:3:5. Into this mixture, while still soft, there were packed as close as they would go stones 2 to 4 inches in diameter, from the river. The next day the forms were taken off and the process repeated. In this way a very economical block was made and one which required a minimum amount of cement. Where stones can be had so cheaply from the near-by river, a solid block of this description costs less than a hollow one, where no stones could be used.

COOPERATIVE WORK.

The growing of fiber crops in cooperation with the insular government is being continued. Seventy-five acres of sisal are planted on government land on the south coast in the arid region. Fifteen acres of this is ready to cut, and during the coming year machinery will be installed for its extraction.

Two crops of sea-island cotton were grown on 50 acres of this land as an experiment. Owing to an unusually dry season the yield was small, barely paying expenses. The crop was sold for 27 cents per pound, f. o. b. Mayaguez.

The 200 acres of table-land above the city of Mayaguez set aside for experiments in reforesting has been partly planted to economic trees. Cabinet woods, nuts, and improved varieties of mango are being planted on this area.

AGRICULTURAL ORGANIZATIONS.

Besides the tobacco experiment station and the sugar growers' station before mentioned, the insular government has organized a bureau of agriculture that is materially assisting this station in promoting better agriculture in Porto Rico. The organization of the agricultural college on land adjoining the experiment station will be of great value to the island, especially in getting results before the farmers and in educating the people along the line of their greatest endeavor.

There should be mentioned also the experimental work of the Guanica Centrale, the Fajardo Sugar Co., and of San Cristóbal Central, all of which have cooperated with this station in the introduction and breeding of sugar canes and the study of their fertilization and cultivation.

REPORT OF THE PHYSIOLOGIST.

By Oscar Loew.

PROTOZOAN LIFE IN SOILS OF PORTO RICO.

The occurrence and rôle of protozoa in soils have awakened much interest in recent years and various hypotheses have been founded on them.

In 1908 M. Wolff[1] studied the influence of irrigation on the protozoan fauna in soils and found 13 kinds of Sarcodina, 19 kinds of Flagellata, and 19 kinds of Ciliata. Many of these protozoa, like some algæ, develop only under the influence of irrigation or in soils continuously moist. Wolff himself does not assume the general occurrence in all kinds of soil of all the protozoan forms observed by him and points out that there are a number of leading forms which are encountered more frequently than others. Among these leading forms are:

Sarcodina: *Amœba terricola*, *Hyalodiscus guttula* and *H. limax*, *Arcella vulgaris*, *Difflugia constricta*, and *Gromia terricola.*

Flagellata: Two kinds of Monas, one of Pleuromonas, one of Chlamydomonas, and four kinds of Bodo.

Ciliata (Infusoria): *Nassula elegans*, *Glaucoma scintillans*, *Balantiophorus minutus*, *Colpidium colpoda*, and *Colpoda cucullus.*

Many questions as to soil protozoa are still unanswered. Do the same species occur in various kinds of soils, or are they different in sandy, clay, and humus soil? To what depth do they occur in different soils? Do acid soils contain all the species which occur in neutral soils? Does heavy liming or manuring with organic mixtures, as stable manure or cottonseed meal, have any influence on the constancy of the protozoan fauna? Do different forms predominate in tropical soils and soils of northern countries? All these questions have not only technical but also some practical interest since microbes, be they useful or injurious, form the chief food[2] for these protozoa which are reported to occur frequently in immense numbers in certain soils of the proper mechanical and chemical qualities. In 1 gram of garden soil Hiltner observed millions of protozoa, mostly amœba.

M. Wolff is of the opinion that the very voracious kind of Flagellata, Bodo, and Monas also can contribute to a purification of soils in regard to parasitic fungi, since these organisms can frequently be observed sucking out spores of such fungi in a germinating condition. Ungerminated fungus spores are generally not digested by protozoa.

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[1] Centbl. Bakt. [etc.] 2. Abt., 33 (1912), No. 11-14, p. 314.

[2] It is asserted that *Amœba limax* also feeds on dissolved organic matter.

Russell and Hutchinson pointed out that the number of microbes in the soil is limited by the great frequency of protozoa, and that if these protozoa are killed by means of disinfecting compounds, as bisulphid of carbon, the increase of microbes developed after a certain time brings on also an increase of ammonia from destroyed organic matter.

Stormer, in testing soils, observed development of amœbæ on neutral agar; he also observed that in soils treated with disinfectants the protozoa were dead.

The series of leading soil protozoa mentioned by Wolff does not, however, according to our observations, occur in all soils. Only a few are of general occurrence under adverse soil conditions. The infusorium most frequently found is *Colpoda cucullus.*

This kind may be considered as the most generally occurring soil infusorium. The writer found this form not only in moderately alkaline soils but even in very acid and stiff clay soils in which not a single other protozoan species could be detected. The same infusorium was found by the writer in the sand dunes of the island of Borkum, in the mountain soils of the Alps, and in the most different kinds of soil in Japan.

This infusorium, on account of its frequency, also awakened the interest of Hutchinson of the Rothamsted experiment station, who informed the writer that he had found it to be not only a general inhabitant of English soils but also of various tropical soils.

Not only is this organism adapted to the deficiently aerated stiff clay soils but also to the dry, coarse, sandy soils. The writer has observed it as the only kind of infusoria in loose sandy soils (from 10 inches depth) of the Porto Rican coast, when the test flask for Azotobacter remained standing for eight days at 24 to 33° C.

Amœbæ were encountered to a moderate extent in various soils, but not in the stiff and acid clay soil of the experiment station, though the infusorium *Colpoda cucullus* occurs in this soil to a depth of 3 inches. When *C. cucullus* is present in a culture with numerous small Flagellata it can be observed feeding upon them, and when overfed it assumes a resting position for digestion.

SOILS AND MINERAL NUTRIENTS.

Pure clay soils, called stiff or heavy clay, are especially frequent in Porto Rico and it is a surprising fact that in spite of very poor aeration many plants can develop well on them. This fact, however, can be explained by the formation of an extended system of surface roots which develop so near the surface of the clay soils that they can procure as much oxygen from the air as they need. Especially may be mentioned the orange, pomarrosa, guava, guamá, bucare, and the banana.

There are greater differences between the soils in tropical and northern climates than one would suppose. In the first place there is the color. An intense red color of soils is very usual in tropical countries, while in northern countries the color is mostly brown, yellowish, gray, or black. This condition is partly due to a higher degree of chemical disintegration, whereby the ferric silicates are further split into the brown ferric hydrate and silica, and the former is further changed to red ferric oxid, and partly to the frequent absence of humus, which would impart a dark color to the originally red soil. In some tropical countries the changes by disintegration go much further and lead to the rather sterile laterite. The absence of humus forms a second characteristic of tropical soils. While in northern countries it is considered as one of the properties of lime in the soils to aid the transformation of organic matters into humus and finally also the oxidation of the humus whereby its nitrogen is rendered available to the roots, such a rôle of lime is not observed in the Tropics. The decomposition of organic matters in the soil is, under the influence of the continuously high temperature, much more energetic than in cooler climates, and therefore the little humus formed is rapidly oxidized again, even in quite acid soils and without the help of carbonate of lime. Only in swamps are large amounts of humus formed in the Tropics.

A third characteristic circumstance for tropical soils is the increased loss of lime caused by the rains at high temperature; in consequence of this there is an excess of magnesia over lime in the soils, a very frequent phenomenon in the Tropics, while in northern countries it forms the exception.

A further characteristic is the unusually frequent acidity of soils. More than 30 samples of soils, chiefly from the western part of the island and partly also from the region of Bayamon, Rio Piedras, and Caguas have been examined, and in all of them more or less acidity was found. Only the sandy soils from the coast and the limestone soils near the coral hills were found neutral. The acidity is not due to humic acid, as often is the case in soils of northern countries, but to an acid clay, and it is produced by the action of carbon dioxid and water at high temperature upon the neutral clay which has to be considered as a combination of the acid clay with various bases, as potash, soda, lime, magnesia, and ferrous oxid.

The degree of acidity can easily be determined by shaking a given quantity, say 50 grams, with a dilute solution of sodium acetate (200 cubic centimenters of a 1 per cent solution), and, after allowing to stand for 24 hours and shaking the mixture repeatedly, filtering the solution and determining the acetic acid set free from the acetate by the acid clay. Thus it was found that for 1 kilogram there would be required from 0.1 to 1.5 grams sodium hydroxid for neutralization, according to the locality.

From this it may be easily calculated how much lime would be necessary for neutralizing an acre of such acid soil to the depth of 5 or 8 inches. In some cases the amount of lime would be so enormous that its application could not be called economical, although the improvement of the soil would soon show in higher yields. While it is, however, not absolutely necessary to lime in one operation to such an extent, an annual moderate liming should not be neglected, since the leaching out of lime by rain is very considerable. It is a noticeable fact that many plants, such as banana, coffee, and orange, have adapted themselves to acid soils in a remarkable manner. Of crops of northern countries, barley, wheat, clover, and alfalfa are examples of plants very sensitive to acidity in soils, while the potato and buckwheat thrive well on moderately acid soils.

A fact further deserving to be mentioned is that the minimum of mineral nutrients required for a satisfactory harvest is lower in the Tropics than in northern countries. In manuring acid soils superphosphate should be replaced by basic slag or bone meal, ammonium sulphate by tankage or well rotted stable manure. In short, acid manures should be avoided and replaced by alkaline manures.

There are three different nitrogen gatherers in the soils of Porto Rico among the microbes that live upon organic matters, which can furnish them the necessary carbon. The first is *Bacterium radicicola*, which enters the roots of leguminous plants and produces there the well-known nodules. The second microbe, which is very important but grows luxuriantly only in soils containing carbonate of lime and which never enters the roots of any plant but lives free in the soil, is Azotobacter, which occurs in several varieties and was found by the writer even in acid solids of Porto Rico. This bacterium grows chiefly near the soil surface and needs air for its life. The third bacterium is the butyric bacillus, which occurs in all kinds of soils, even in the stiffest clay and most acid and most alkaline soils. The writer found it in clay soils at 18 inches and once even to a depth of 30 inches. This bacillus can live without air and can multiply under the condition that some fermentable material, as sugar or starch, is furnished to it by decaying roots or organic manures. It produces a most energetic fermentation in a solution of glucose, whereby butyric and acetic acids and further carbonic acid and hydrogen gas is produced. This bacillus forms spores which can remain a long time alive in the soil and awake to activity as soon as from a decaying root some suitable organic matter reaches them. As a nitrogen gatherer, however, it can hardly be compared with the great activity of Azotobacter and *Bacterium radicicola*.

SUPPLEMENTING THE MINERAL NUTRIENTS IN THE TROPICS.

It is an old observation that most persons coming from northern countries to settle in tropical regions gradually decrease in body weight, due to the dwindling of the muscles. Also reduction of the number of red corpuscles has been observed, but the primary physiological causes of these phenomena have never been sufficiently elucidated.

A generalization for all tropical countries without exception would be unjustified, since the proximity of mountains to coast regions modifies considerably the effects of tropical heat. The western part of Porto Rico has such a favorable position. It is true the summer temperature rises almost daily to 89° F., but during the night there is a pleasant cool wave from the mountain regions near by, making possible a deep, sound sleep and banishing the beginnings of tropical neurasthenia which might develop in some sensitive persons. Even in July and August there is the cool night breeze, and the temperature sinks to 65° F. Besides, disease-breeding swamps are absent in Porto Rico. Indeed, many of the Americans who have lived in Porto Rico for years are still perfectly healthy, but some individuals encounter more difficulty in becoming acclimatized than do others.

Certain effects of tropical climates, however, are noticed also in Porto Rico; thus sometimes the tropical anemia occurs, especially with natives, and the tropical edema (swelling of the lower extremities), which develops sometimes with persons that emigrate to Porto Rico at a more advanced age.

In the opinion of the writer, the primary cause of the decrease of body weight is a weakening of the functions of all glandular organs in the gastro-intestinal tract, caused by drinking daily the large amounts of water a perspiring man is continuously forced to take. It would evidently be better to drink a physiological salt solution containing 0.6 to 0.8 per cent sodium chlorid instead of plain water. But another cause of weakening is the daily consumption of food too poor in lime and too rich in magnesia, as, for instance, rice. Since the writer, in conjunction with Prof. Emmerich, had observed with various persons increase of body weight by improvement of digestion after taking daily 1.5 grams of calcium chlorid, it was of interest to observe whether this supplementing of the mineral nutrition with calcium salt would also have such an effect in the Tropics. A series of experiments were made with a number of persons who were given 1.5 grams calcium chlorid per adult daily in the drinking water. The results were striking in most individuals, showing gains in weight and improvement in some cases where there had been indigestion and poor assimilation of the food.

REPORT OF THE CHEMIST.

By P. L. Gile.

INTRODUCTION.

Except for some analyses made for the other departments, the chemical work the past year has been directed to those problems in soils and plant nutrition outlined in the previous report. It is expected that two of the investigations started about three years ago will be completed the coming year.

While progress has been made in all the investigations, the efficiency of the work along some lines is still greatly affected by lack of equipment for conducting vegetative experiments in pots. Although a glass house is not essential for the proper conduct of such experiments here, protection from heavy rains, insects, birds, and rats is essential.

The equipment for soil and fertilizer studies has been increased during the year by the construction of 30 cement cylinders 3 feet in diameter, sunk in the ground to a depth of 3½ feet. At the present time certain vegetative experiments that can not be conducted in field plats are being carried on in these cylinders. This method of experimentation is satisfactory for the study of certain problems, but is not generally applicable to all work.

The necessity for additional equipment increases from year to year.

SUMMARY OF THE WORK.

During the year 160 samples, including soils, plant ashes, limestone, canes, waters, and certain miscellaneous materials, have been analyzed.

The work on the effect of strongly calcareous soils on the growth and composition of certain plants will probably be prepared for publication the coming year. It is expected that a preliminary report on the bat guanos of Porto Rico will also be prepared during that time. The investigations that are being continued are those on the action of lime in inducing chlorosis, the effects of various ratios of lime to magnesia on the growth of plants, the treatment of the red clay soils, and the chlorosis of sugar cane. No new problems have been taken up the past year, but progress has been made on all the above problems.

In connection with the work on the chlorosis of sugar cane, field plats were established at Central Cortada last year for treating the cane with ferrous sulphate in various ways. These plats will not be cut until January, 1913, but at the present time marked differences are apparent in them, those sprayed with ferrous sulphate and those receiving the mixture of stable manure and ferrous sulphate appearing the best. A further field experiment of 5 acres on this subject is being started at Central Cortada. Thanks are due to the American Steel & Wire Co., which has kindly furnished 2,500 pounds of iron sulphate for this purpose.

The plats established last year to study the best treatment of the red clay soils will probably be cut in December of this year. From the appearance of the plats at the present time it does not appear that any of the treatments tried at Hormigueros are going to be very effective in increasing the yield of sugar cane on the unproductive soil. Differences, however, are apparent in the fertilizer plats established at Anasco on the more productive soil.

In the study of the action of lime in inducing chlorosis some interesting results have been secured with rice. The field plats at Central Cortada, mentioned above, also promise to give results bearing on this problem.

THE RED SANDY SOIL OF PUEBLO VIEJO AND BAYAMON.

Certain soil analyses made during the year that are not related directly to any of the above lines of work are given below as being of interest. The samples were taken from citrus groves in Pueblo Viejo and Bayamon, and, while they are by no means representative of all the soil in this district, they are of the red sandy soil, which is often found underlain by a rather stiff clay subsoil at a depth of several feet. This type of soil is a rather fine red sand, which is darker in color and more loamy in texture when it contains considerable organic matter and has a tendency to pack when lacking in it. The following samples are all of this type: Nos. 492 and 494 are surface soils of this type taken at Pueblo Viejo; samples 493 and 495 are the respective subsoils; Nos. 539 and 540 are the soil and subsoil from a grove in Bayamon; Nos. 541 and 542 are both surface samples from another grove in Bayamon, where pineapples are planted at present. The samples of surface soil represent the first foot of soil and the subsoil the second foot. The analyses of the soils by digestion with hydrochloric acid of specific gravity, 1.115 are given in the following table:

Analysis of red sandy soils of Pueblo Viejo and Bayamon.

	Soil, Lab. No. 492.	Subsoil, Lab. No. 493.	Soil, Lab. No. 494.	Subsoil, Lab. No. 495.	Soil, Lab No. 539	Subsoil, Lab. No. 540.	Soil, Lab. No. 541.	Soil, Lab. No. 542.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Insoluble residue	90.14	78.20	86.66	77.40	85.29	79.40	77.84	77.31
Potash (K_2O)	0.04	0.08	0.02	0.06	0.01	0.08	0.07	0.01
Lime (CaO)	Trace.	Trace.	Trace.	Trace.	.26	.13	.33	.22
Magnesia (MgO)	Trace.	Trace.	Trace.	Trace	Trace.	Trace.	Trace.	.12
Ferric oxid (Fe_2O_3)	2.02	3.99	2.94	4.79	5.72	7.86	9.65	9.73
Alumina (Al_2O_3)	4.12	12.71	5.67	10.66	2.88	6.68	1.33	1.69
Phosphorus pentoxid (P_2O_5)	.06	.04	.05	.06	.01	.01	.02	.02
Loss on ignition	3.89	5.79	5.23	6.92	5.25	6.10	10.44	11.11
Total	100.27	100.81	100.57	99.95	99.42	100.06	99.68	100.04
Nitrogen (N)	.06	.07	.07	.06	.12	.08	.22	.21
Carbon dioxid (CO_2)	.00	.00	.00	.00	.00	.00	.00	.00
Reaction to litmus	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)

(1) Strongly acid.

In regard to the chemical character of these soils the following facts stand out plainly: The soils are strongly acid; they are particularly low in magnesia, potash, lime, and phosphoric acid; there is much more potash in the subsoil than in the surface soil; the nitrogen content of the two soils from Pueblo Viejo is low and that of the two soils from Bayamon is fair to good.

The subsoil is of slightly more clayey nature than the surface soil and is less weathered. The fact that there is more potash in the subsoil than the surface soil would point to this, although this might also be due to the potash being leached into the lower soil. The greater percentage of alumina and the greater loss on ignition in the subsoil than the surface soil also point to the second foot containing more clay of zeolite character.

While a chemical analysis is never a safe guide for fertilization, these particular analyses seem to substantiate results obtained by the horticulturist of the station in fertilizer experiments on soils 492 and 539, which show that this type of soil needs a complete fertilizer. The samples from Bayamon are particularly low in phosphoric acid.

That these soils would be much benefited by liming there is little doubt, since they are very deficient in lime and also strongly acid. While many citrus trees are making a good growth on acid soils, it is generally considered that the optimum condition for their growth is a neutral or slightly alkaline reaction. A chance application of lime was once made to soil 539, and the grower reported that following the application the trees receiving the lime put forth new growth, in strong contrast with unlimed trees. Liming is being tried on soil 492, but no results have been reported as yet.

The very small amount of magnesium in these soils makes it probable that a fertilizer containing magnesium would give good results. Rigaux found that Belgian soils containing 0.01 to 0.04 per cent MgO gave increased yields with a magnesian fertilizer.[1] The double manure salt of potassium and magnesium might thus give a better result than the high-grade sulphate of potash. If the land were limed with a limestone containing magnesium, however, enough magnesium would be supplied for the needs of the trees.

This type of soil is generally low in organic matter and is especially in need of it for holding the fertilizer applied and for improving the physical condition. The growth of leguminous cover crops on this type of soil has been strongly recommended. Sword beans grow well on this soil, and in spite of the acid condition develop enormous nodules. These nodules were examined by the pathologist and found to be true bacterial nodules, although nematode excrescences were also found on some roots. By keeping a leguminous cover crop in the citrus orchards on this type of soil the soil conditions would be much improved and considerably less nitrogen would be required in fertilizing the trees.

To secure the best results from citrus orchards on this type of soil heavy fertilization is required; lime and organic matter is also needed. It is recommended for citrus culture that these soils be limed every few years, that leguminous cover crops be grown, and that heavier fertilization be practiced here than on the richer soil types. Basic slag should serve well as a source of phosphoric acid because of the acid character of the soil, and for the same reason sodium nitrate or dried blood should serve better as sources of nitrogen than ammonium sulphate, which is physiologically acid.

ESTIMATION OF LIME IN PLANT ASHES.

In connection with the investigation on the effect of strongly calcareous soils on the ash composition of various plants, the acetate method for the determination of lime in plant ashes has been tested. This method for determining lime in the presence of iron, alumina, and phosphoric acid consists in precipitating the iron and aluminum as phosphates by ammonium acetate in slightly acid solution, and then precipitating the lime as oxalate in the presence of any phosphoric acid that has not been removed by the first precipitation.

The official method [2] for the determination of lime in plant ashes differs from the above in that a complete separation of the phosphoric acid is effected before the lime is precipitated by adding sufficient ferric chlorid to combine with all the phosphoric acid. Here, however, a bulky precipitate of ferric phosphate results which has to be reprecipitated to free from lime.

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[1] Bul. Assoc. Chim. Sucr., et Distill., 26 (1908), No. 6, p. 444.

[2] U. S. Dept. Agr., Bur. Chem. Bul. 107, rev., p. 22.

The acetate method is much quicker, since the precipitate of ferric phosphate is so small that it is easy to handle and does not have to be reprecipitated. This method is given by Wiley[1] for the determination of lime in mineral phosphates, is used by König[2] for determining lime in plant ashes, and has lately been again suggested by Thompson and Morgan[3] for this purpose.

A comparison of the acetate and official method for the determination of lime in plant ashes was made by Mr. Ageton on seven samples of ash from cassava roots and stems. The results are given in the accompanying table:

Lime and magnesia in ash of cassava.

No. of sample.	Official method.		Acetate method.	
	CaO.	MgO.	CaO.	MgO.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
325	12.51	8.82	12.50	8.78
327	14.94	8.44	14.94	8.35
328	18.20	8.89	18.15	8.80
329	25.02	12.35	25.00	12.20
330	27.30	11.14	27.21	11.23
331	26.98	11.73	27.05	11.74
332	27.10	12.33	27.15	12.39

These results show that the acetate method is fully as accurate as the official method for the determination of lime and magnesia in plant ashes. Since these samples contained from 15 to 18 per cent of P_2O_5 and only 0.63 to 1.72 per cent of Fe_2O_3, it is evident that only a small portion of the phosphoric acid was removed before the precipitation of lime in the acetate method, and that the further addition of ferric chlorid, with its attendant difficulties, as prescribed by the official method, is unnecessary.

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[1] Wiley, Principles and Practice of Agricultural Analysis. 1895, vol. 2, p. 24; 1908, 2. ed., vol. 2, p. 231.

[2] König, Untersuchung landwirtschaftlich und gewerblich wichtiger Stoffe. Berlin, 1906, 3. ed., rev., p. 201.

[3] Thompson and Morgan Jour. Indus. and Engin. Chem., 3 (1911), p. 398.

REPORT OF THE HORTICULTURIST.

By C. F. KINMAN.

CITRUS FRUITS.

Work with this crop has included the continuation of the cooperative fertilizer experiments, experiments with stocks, marketing problems, and orchard management (Pl. II, fig. 1).

An experiment was conducted to determine the practicability of packing for shipment the uncultivated oranges on the coffee plantations where they are grown instead of selling the ungraded fruit at small prices to shippers at seaports. The careless method now practiced in picking and delivering to market results in heavy losses both in the decaying of badly injured fruit before packing and in decay before it reaches the northern market. Heretofore the farmer has been paid from 30 to 60 cents per box for an excellent product after he has delivered it to a coast town, and the heavy decay often results disastrously with those who buy for shipment. The marketing work carried on during the past year was largely confined to one coffee plantation 2 miles from the coast. This is a typical small coffee plantation, being hilly and wooded and having the orange trees, which grow wild, scattered through it. The crop was much below normal, there being only 90 boxes of packed fruit and 3 of culls harvested. As is the rule, this wild fruit, which grows among the larger coffee shade trees, is well protected from the wind and is bright and clean, being free from insects and russet. The culled fruit was that which had been scarred by insects or diseases while the fruit was young, or fruit with "creased" or ruptured inner skins. The laborers employed for tending the coffee have less work with it during the orange-picking season than during other parts of the year and they were able to do all the work with the fruit except that instruction was necessary for the packing. The equipment necessary for handling the crop was largely homemade and inexpensive. As this was the first experience the laborers had had of this nature, the work progressed slowly, but the grade of their work improved rapidly. The crop was marketed in three lots. From the first lot 17 per cent decay was reported, and from the other two all fruit was reported as being sound. The average price received per box for the entire crop was $1.75, which compared well with many sales of cultivated fruit and was much in advance of that paid for wild fruit, which was marketed in the customary way. Half of the oranges for the last shipment were allowed to cure in open bins for three days before packing, while the other half were picked and boxed immediately before shipping. No decay from either lot was reported by the salesmen. The experience from the trial indicates that this excellent uncultivated fruit can be cheaply harvested and marketed by the laborers on the plantations with but little loss of fruit by decay and that the profits will be much in excess of that received by following the old method, as the shipped boxes bring satisfactory prices and the amount discarded before shipping is materially decreased by careful work.

In this locality where the oranges ripen during the dry season the skin is dry and tough if the fruit is left on the tree until from January to March and but little, if any, curing is necessary before shipment. In a demonstration to show the results of skin injuries, three boxes of sound and three of skin-punctured fruits were packed and stored 11 days. When opened 3 per cent from the sound boxes had decayed and 34 per cent of the punctured fruits.

The cooperative fertilizer experiments have been practically closed and the data are being arranged for publication. In the two groves where the work has been under way the fruit from each crop was counted and weighed and the influence of the different treatments found to be more pronounced than last year. The plats receiving a complete fertilizer yielded much better, in some cases 100 per cent more, than those receiving an incomplete fertilizer, and all fertilized plats produced much more than the check rows. These results would be expected, as a chemical analysis of the soil shows that it is exceedingly low in fertility, but little more than traces being found of potash and phosphates. The product from the plat receiving potash and nitrogen was much less than that from any other plate receiving an incomplete fertilizer. But small differences have been observed between the use of muriate and sulphate of potash, and the plats to test the merits of these elements are being continued.

Work with the various types of citrus stocks has been continued, and wide differences in thriftiness of seedling types have been noted. The test is on a slightly sloping site, where sour-orange, sweet-orange, rough-lemon, and grapefruit seedlings were set in a heavy clay which does not drain well. The growth of all was unsatisfactory during the months of excessive rains, but during the drier months the lemon seedlings grew well, the sour orange was somewhat less thrifty, while the sweet orange and grapefruit, which were about equal, made a slow and unsatisfactory growth. Plantings of the different types have been made in a more favorable soil for testing under orchard conditions.

A variety orchard which was set several years ago has proven so unsatisfactory that it has been removed during the past year. The

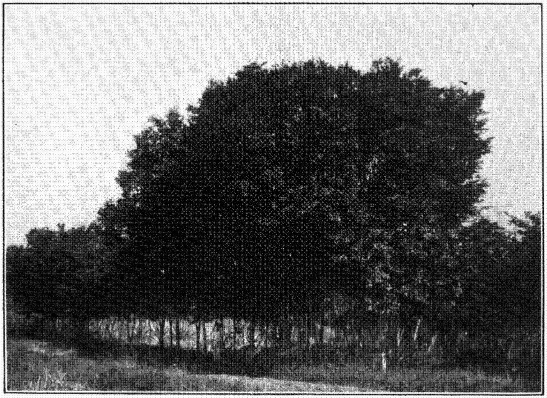

FIG. 1.—GUAMA, IGNA LAURINA, AS A WINDBREAK.

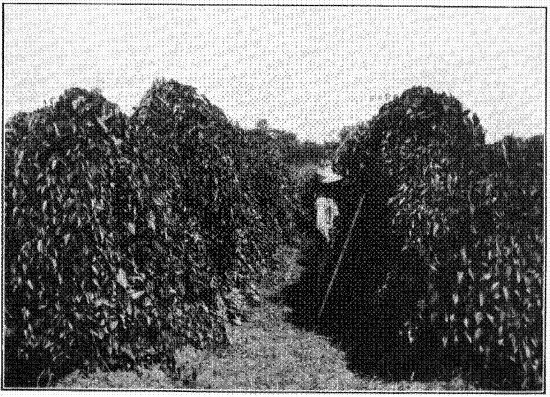

FIG. 2.—VARIETY TEST OF YAMS.

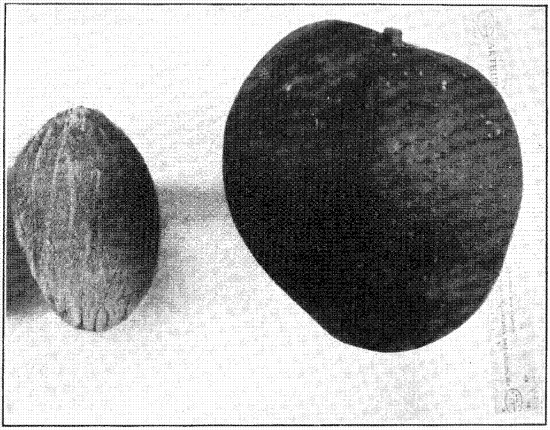

FIG. 1.—MULGOA MANGO.

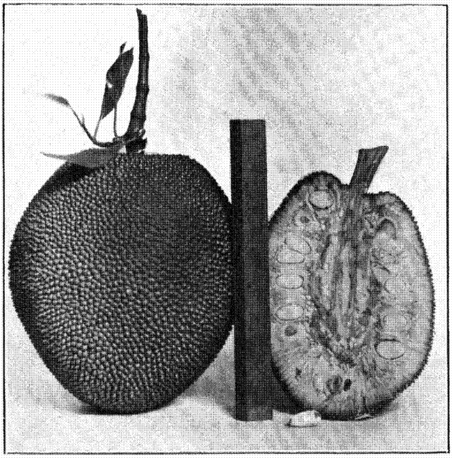

FIG. 2.—JACK FRUIT.

SOME PROMISING FRUITS INTRODUCED BY THE STATION.

location of this orchard was on an elevated area, where the soil is a heavy clay which drains poorly. During the time of drought, which continues through most of the winter, the roots are forced downward, where they can not thrive during the wet summer, when the water table is very near the soil surface. Hart late oranges and Duncan and Marsh seedless grapefruit withstood the conditions best.

MANGOES.

A number of varieties have been imported this year and set in the testing orchard. Sixty-four foreign types are now being cultivated at the station, the larger part of these being East Indian varieties. Plantings have been made to test commercially a number of varieties, which, from single trees now a few years old, indicate that they will succeed and prove to be profitable. Both native and imported types seem well suited to the conditions here, thriving on a variety of soils where other crops are not profitable and on land which is at present unproductive.

A number of varieties fruited this year and the crop on the fruiting trees was light, except with the varieties Sandersha, Mulgoba, Ameeri, and Cambodiana. A number of varieties have never borne, though the trees are from 4 to 6 years old and very thrifty. The varieties which fruited were Sandersha, Mulgoba, Mulgoa (Pl. III, fig. 1), Sufida, Bulbulchasm, Ameeri, Divine, Cambodiana, Totafari, Amini, D. B. Alphonse, all of which possess the favored qualities of the eastern mango and are far superior to our native types. A number of these imported trees, though never having been pruned, are very symmetrical and promise to be of value for ornamental use where a tree of dense, heavy foliage is desired.

As the value of different varieties is demonstrated, the choice kinds are being propagated for distribution at a nominal price to planters. In connection with the production of these trees, different methods of propagation, including budding, inarching, and grafting, are being tested. The grafting of potted or nursery seedlings has been successful this season.

COCONUTS.

In cooperation with Guanica Centrale, a coconut fertilizer experiment has been started in a grove situated near the coast between Mayaguez and Anasco. The conditions in this location are almost ideal, the soil being a light sandy loam. The field is but a few feet above the sea and lies almost level, and the trees are old and at present produce but small crops. For the work with fertilizers, 7 plats have been set aside, each containing 50 trees. Experiments with cover crops, cultivation, nursery problems, and the variation in productiveness of individual trees, will be carried on in connection with the fertilizer experiments.

Until within recent years but little cultivation was given to the coconut groves in Porto Rico, but as the nuts have greatly increased in popularity in the markets during the past year, now selling as a first-grade product, excellent profits are being realized from productive groves and attention is being given to fertilization, cultivation, drainage, etc., with good results.

ROOT CROPS.

Work with root crops, including sweet potatoes, yautias, dasheens, yams, and arrowroot, is being continued. Each of the 20 varieties of sweet potatoes grown during the last year produced a fair crop, but field rats were so troublesome that it was impossible to get an accurate record of the production. At the beginning of the long winter drought another planting was made, but the resulting crop was too light to be profitable. During the present season plantings of all varieties have been made at the station and also on a sandy soil near the beach north of Dorado.

The effect of commercial fertilizers on the yield of yams (Pl. II, fig. 2) was not decisive on the last crop, though interesting data have been taken from the work and the experiment is being continued. The influence of distance and size of tubers planted, which was tested with the variety Potato, has been very marked on the yield. Where hills were planted 2 by 2 feet on level land the average production per hill was 2.46 pounds, and where planted 4 by 4 feet the average production per hill was 5.11 pounds. Calculated per acre, the closer planting gave over 13 tons of tubers, while the yield from the wider planting was but little over half as much. In the ridge plantings the hills which were separated 20 inches gave 5.07 pounds of tubers per hill, while when planted 10 inches apart the yield was 3.93 pounds per hill. Where medium sized tubers were planted the average weight per hill was 5 pounds, and where small tubers were planted 4 pounds per hill. This variety should be very profitable in this locality, as the yield is heavy and the starch content of the tubers is 23½ per cent.

With the large number of varieties of yautias and dasheens cultural, fertilizer, and variety tests are being continued. This crop seems to be well adapted to our conditions and all varieties made a splendid growth.

EUCALYPTUS.

During the past year 20 varieties of eucalyptus have been planted on high sloping land to compare with the same varieties which have been growing on low land for a number of years. Each variety started well and with the exception of a few varieties all are making a satisfactory growth. The kinds making the most vigorous growth on the high land are *E. robusta*, *E. tereticornis*, *E. rostrata*, and *E. paniculata*. On the lower poorly drained soil *E. robusta*, *E. piperita*, and *E. tereticornis* are the only promising ones, though many trees of other varieties are living and making some growth. While the seedlings which were set during the past year were small, crown galls developed at or near the crown of a number of the varieties, in some cases increasing the diameter of the stem at that point to twice its normal size, but up to this time no apparent damage has resulted, the most thrifty trees often having the largest galls.

VEGETABLES.

Studying the influence of Porto Rican conditions on vegetables from seed imported from the north has been continued with interesting results. The second generation Early Valentine beans grown here were much inferior, both in vigor of the plants and in production, to the crop grown from the imported seed, but during successive generations there has been a gain in productiveness of the former, until the eighth generation has exceeded the yield from the first generation. Duplicate plantings from the original seed, from the second, and from the eighth generation were made in Porto Rico and in Minnesota during the summer and the harvest results ranked the same with different generations. The behavior of White Velvet okra has been in some ways the opposite of the beans, as with this crop the second generation has in different plantings resulted in the most vigorous plants and heaviest yield, the successive generations gradually degenerating. With other crops under observation the results are not pronounced.

The influence of subirrigation and surface irrigation was tested for garden practice by watering one area by surface ditches and the other with cement tubes. The tubes were 4 inches in diameter and 12 inches long and were laid at the entrance gate 8 inches deep and falling about an inch in 75 feet. A number of varieties of tomatoes, peppers, beans, onions, and eggplants were grown, each of which produced better and were much less expensive to cultivate in the subirrigated area. Crops growing above the tubes fruited much more heavily during the wet season than on the other land adjoining, as the tubes seemed to assist in draining or in aerating the heavy, wet soils.

Comparing a number of types of peppers which are common in the Porto Rican gardens with the most popular northern-grown varieties demonstrated that at least during the season of heavy rains the Porto Rican peppers were much more vigorous than the imported varieties and produced much heavier crops, while the texture and flavor of the pods from imported varieties was not superior to the native kinds.

REPORT OF THE ASSISTANT HORTICULTURIST.

By T. B. McClelland.

COFFEE.

The high coffee prices now prevailing have meant prosperous times for the Porto Rican coffee growers. More than 40,000,000 pounds were exported in the past fiscal year, having a valuation of 16.8 cents per pound. This stands in strong contrast to the valuation in 1903 of 11.2 cents per pound. It means that the coffee grower's net profits are now just twice what they were then. The exports to the States, though small, have increased considerably.

Frequently requests for information on coffee planting are received. To cover some of the points in question a circular[1] embodying suggestions along this line has been prepared for distribution.

The lines of investigation with coffee formerly undertaken are being continued, and, as many of the young trees are now producing, very interesting and valuable data as to yield are being accumulated. Notes are being taken also as to height and rate of growth of plats of trees which have received different fertilizer combinations or different cultural methods.

Though differences can be seen in the coffees which are due to differences in fertilizers or methods followed, in some cases these seem very small after two years' treatment, in comparison to the differences caused by the position of the tree; that is, generally speaking, whether it is found on the upper or lower part of a slope. On many slopes in the station plantings the trees below are in fine condition and those above poor. In such cases cultivation and the application of complete fertilizers have so far failed to overcome these unfavorable conditions, but in some instances have ameliorated them.

With such crops as coffee from slow-growing plants, which continue producing for many years, definite conclusions can be drawn only after a large amount of data is at hand.

Among the plantings of foreign coffee (*Coffee arabica*) the Padang is unusually fine, some of the trees being more than 11 feet high at a little over three years from seed. Though there are great variations in the trees of Erecta, some are exceedingly handsome and producing well. The Columnaris trees have made excellent growth and are fine specimens of coffee trees (Pl. I, fig. 1). Though they are of sufficient age to be producing heavily they are giving only a minimum yield.

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[1] Porto Rico Sta. Circ. 15.

There are in nursery beds at present fine young plants of *C. liberica* and *C. dewevrei* in sufficient numbers to make plantings which should be valuable as tests of these species under our conditions.

The experiment of felling the coffee shade on a part of the college farm to rid the coffee of the destructive ant (*Myrmelachista ambigua ramulorum*) has been highly successful. At the very edge of the felled plat a large Ceiba tree was left standing. This tree still harbors these ants and some are to be seen in small branches which have fallen from it and also in some of the coffee trees under its spread. Otherwise the ants in this plat have been practically exterminated, a long search revealing only rare instances in which a few ants of this species are to be seen in the coffee trees or guamá renews. On the whole, the coffee looks in a somewhat poor condition.

The coffee seed tests begun last year were repeated, with the result, as on previous tests, that seed that had been severely dried showed a rapid loss of viability. From those kept over concentrated sulphuric acid on the first test, which was at the end of two months, no seed germinated, while of two checks, one kept in the open air and the other over water in a closed jar, each gave a 95 per cent germination.

During the fall, seed of a number of imported coffees were distributed to coffee growers over the island.

VANILLA.

In the vanillery 12 plants blossomed this year, including *V. planifolia*, *V. pompona*, *V. eggersii*, *V. phantha*, and vanillas of undetermined species. In the spring some very dry weather caused many fruits that had set to drop, some vines losing all pods. It was gratifying to note, however, that no pods of *V. planifolia* were so lost. Cuttings of this species have become available, so that there are at present some 20 plants of *V. planifolia* at the station. Why the cultivation of this crop has never been undertaken commercially in the island is unknown, since very fine vanilla has been grown here as a curiosity in private gardens. The prospects for its successful culture seem very good.

Some cuttings have been distributed, but it was thought best to distribute these sparingly, as the vines are needed for a thorough test at the station.

RUBBER.

Of the plantings of 200 trees of *Castilla* sp. made in 1903 less than 100 have survived to date. The land in which they are planted slopes down to a small stream. On the lower land near the stream the trees have grown well, but a little back from it and up the slope the greater part of those that have not died have made very poor growth. Measurements in April showed for the whole an average girth of 18 inches at 3 feet above the base. Only 31 trees were of sufficient girth to permit tapping. The yields of rubber have been small.

New plantings have been made of *Castilla panamensis*, *C. lactiflua*, and *Castilla* sp. from Mexico.

Seed of *Castilla* sp. have not been distributed, as more and varied plantings are necessary before any results can be hoped for. Complaints of seed not germinating are frequently heard. It was found that the viability could be prolonged considerably by keeping the seed between layers of fine soil and charcoal, mixed and slightly dampened. Two lots of seed were simultaneously picked, pulped, and washed. One lot was spread out in a thin layer in the open air, the other packed in mixed soil and charcoal. Seed from the former germinated well for less than two weeks, and in a little more than five weeks quit germinating altogether, while those from the latter still showed a 93 per cent germination. After this, however, the percentage germinating fell rapidly.

CACAO.

The yields of cacao have been recorded and show an increase over those of the year preceding. The average of six pods per tree is very small for trees 8 years old. Cacao, S. P. I. 11656, planted out nearly eight years is now just beginning to produce. (Pl. IV, fig. 1.) The pods are not large, but the seed is of average size and in section is pure white, indicating superior quality.

MISCELLANEOUS.

The station has been very active in introducing new fruits into Porto Rico, some of which have fruited and promise to prove valuable acquisitions. (Pls. III and V.)

REPORT OF THE PLANT PATHOLOGIST.

By G. L. Fawcett.

BANANA DISEASES.

The effect of the use of "seed" free from disease and of the ordinary unselected seed is being tried, and also the effect of cultivation and fertilizer in keeping down the common disease of this plant. No organism has been found here which inoculation has shown to be clearly parasitic when introduced in pure culture. It seems probable that unfavorable soil conditions may weaken the plant and render it susceptible to some slightly parasitic bacteria and fungi which it ordinarily is able to resist. Such soil conditions include excess of water in the soil and continued growth for a number of years among the old decaying stumps left after the removal of the fruit. The inability of the Fusarium commonly occurring in the diseased tissue to act parasitically even when introduced in considerable quantities into healthy plants has been demonstrated repeatedly in this work, although a slight parasitism of this fungus in older or weakened plants has been observed.

CITRUS-FRUIT DISEASES.

The anthracnose of grapefruit was somewhat troublesome this year, perhaps favored by unusually heavy rains. It was found that the mere presence of the spores of the anthracnose fungus did not mean that the spots would be produced on the fruits. Fruits covered with the spores remained healthy unless punctured slightly with a needle, in which case they developed the spots at the point of injury. It would seem from this that the wounds made by scales or other insects must greatly favor this spot of the fruit.

COFFEE DISEASES.

The work with the West Indian coffee diseases has been confined to the search for another form of *Stilbella flavida* on some of the shade trees, especially the guava, *Inga vera*, which is used extensively where the disease is most destructive. The disease seems to be most abundant under this tree in some plantations with mixed shade. Inoculations into coffee leaves with various fungi suspected of representing such a form of Stilbella have been made, but without positive results. There are certain problems in the distribution of this disease which would be more readily explained through the existence of such an intermediary host. As the guava is a valued shade tree, experiments as to the effect of its removal on the disease are hardly to be recommended, in the absence of proof of any bad effect from their growing in coffee plantations.

A root disease has been found of a different type with respect to the causal organism from the common form. In its action it is essentially the same as the usual root disease, though perhaps more parasitic, attacking and destroying young plants which the other often leaves unharmed. The fact also that it destroys certain quick-growing herbaceous plants which may be used in the experiments has made the study of the effect of soil treatment easier by giving quicker results. A long time, often several months, is necessary for the disease to destroy large coffee trees which have been used in this work hitherto. It is planned to publish separately an account of the work done with coffee diseases.

COCONUT DISEASES.

In some work with the diseases of the coconut palm an interesting point was observed in connection with the "cut" leaves, quite common on these trees, which are generally thought to be injured by the attacks of one of the common coconut beetles. It was found that the injury, at least in the groves near Dorado, was due to *Thielaviopsis ethaceticus*, the common pineapple fungus of cane. This fungus was found to penetrate the still unfolded young leaves and produce a discolored softened spot, often extending entirely through the leaf, a distance of 2 or 3 centimeters. Soon after the growth has carried the tightly folded leaflets up so far that expansion is possible they are broken off by the wind at the point of attack, and the gnawed appearance is given the leaf.

T. ethaceticus, together with a yeast, was invariably isolated from the affected tissues. Inoculations with the fungus into the unfolded leaves of trees at Mayaguez have given the characteristic cut appearance to the leaves. No infection resulted from inoculations with the accompanying yeast. There can be no doubt that, owing to the compact arrangement of the leaflets, any organism capable of producing decay in their tissues could produce the same appearance, and it is possible such exist. In the case under consideration, however, the pineapple fungus caused the injury. Petch[1] has reported it as causing bleeding and in some cases a decay of the trunks of these trees, and it has been isolated here previously from the tissue below the leaf bases of slow-growing trees. It is probable that the same fungus may sometimes cause bud rot. The trees with "cut" leaves were

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[1] Circs. and Agr. Jour. Roy. Bot. Gard. Ceylon, 4 (1909), No. 22.

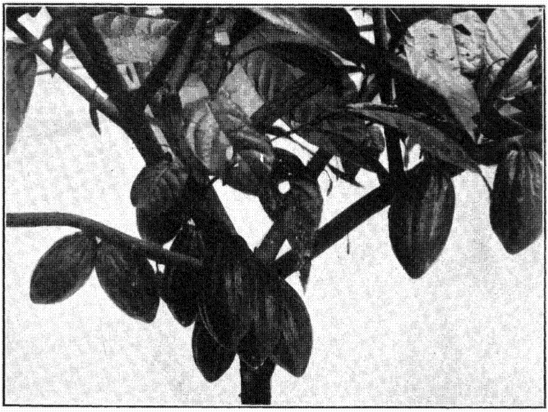

FIG. 1.—FIRST CROP OF GUADELOUPE CACAO.

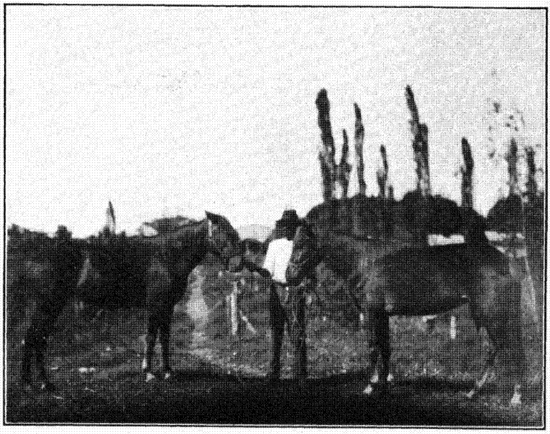

FIG. 2.—TYPES OF NATIVE MARES.

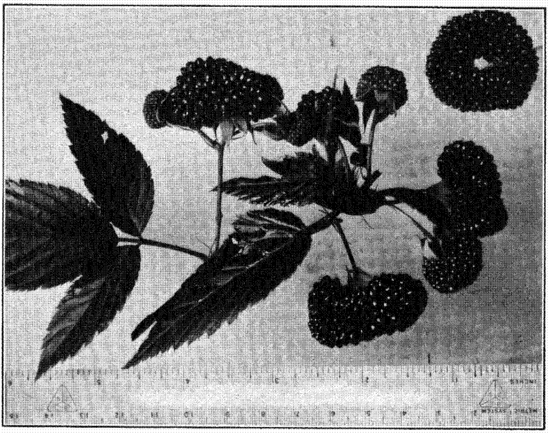

FIG. 1.—RUBUS HYBRID INTRODUCED FROM QUEENSLAND.

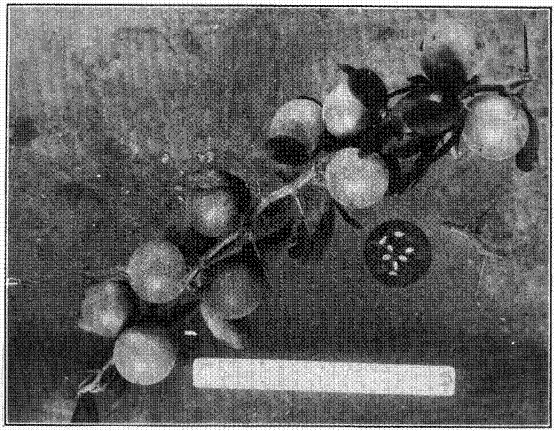

FIG. 2.—KAI APPLE, ABERIA CAFFRA.

SOME PROMISING FRUITS INTRODUCED BY THE STATION.

said by the owners of the grove to invariably succumb to bud rot after awhile. But it seems less probable that a tree in ordinarily favorable conditions would be injured, for the reason that the growth of the tree itself, with the consequent outward movement from the soft, easily injured tissues of the bud is a great safeguard against rot-producing organisms. The inoculations into the bundle of leaves were carried upward at the rate of 2 to 3 centimeters a day. The more rapidly growing tree also casts off more of the old fungus-harboring leaves. The groves where the disease occur are on very poor soil and have received no fertilizer. The yield of nuts is small and of poor quality. It is planned, with the cooperation of the owners, to try the effect of fertilizer on the unhealthy trees. Many of the apparently diseased trees have been felled and the affected parts burnt, but such sanitary measures promise little benefit if the fungus has already obtained a foothold in most of the other trees, as seems probable. It seems impossible to remove the diseased parts without destroying the tree.

REPORT OF THE ENTOMOLOGIST.

By C. W. Hooker.

The previous station entomologist, Mr. W. V. Tower, resigned July 1, 1911, and from then until November 2, 1911, the only work along this line was with bees. Few notes were available and very few insects in the collection were determined, hence progress has been slow. During the past year a system of note filing has been introduced, so that any information gathered on the various insects may be readily found. A large number of insects have been collected and preserved and several hundred have been sent to the United States National Museum for determination, duplicates being retained in the station collection for consultation.

During the past year the May beetles, changa, sugar-cane borers, and ants have as usual been most troublesome and their control most difficult. There have been local outbreaks of the cabbage worm, *Pontia monuste;* bean leaf-roller, *Eudamus proteus;* bean leaf-beetle, *Cerotoma trifurcata;* corn-ear worm, *Laphygma frugiperda*, and cucumber beetle, *Diabrotica vittata*, and on the south side of the island the green *Diabrotica graminea* has been very abundant, but has confined its attention mostly to weeds. Adults of a round-headed beetle, probably *Bostrychus monachus*, have evidently been boring at certain seasons for some time past in the station grapefruit trees, for many old healed-over wounds were found. This beetle was also taken boring in pigeon pea and gallito, *Agati grandiflora*, and is reported in flamboyant, coffee, and citron from other parts of the island. Five to 10 burrows were found in grapefruit and 20 burrows were found in a single stalk of pigeon pea, but no eggs, larvæ, or pupæ could be discovered, hence the principal host is as yet unknown.

The principal work of the past fiscal year has dealt with insect pests of coffee, mango, citrus fruits, and sugar cane, and with beneficial insects and fungi.

COFFEE.

The most troublesome coffee pest is an ant (*Myrmelachista ambigua ramulorum*), a species originally described from Culebra, Arecibo, and Utuado, P. R., where " it was nesting in rather populous colonies in hollow twigs of trees, especially the sea grape (*Coccoloba uvifera*) and ' torchuelo ' (*Bicuda buceros*)." Its habits in the coffee-growing region are similar. Here it lives mostly in the twigs and under pieces of loose bark on the trunk of the guamá, a hitherto popular coffee shade tree, and in dead wood on the coffee. It feeds largely on honeydew from two coccids, one a mealy bug, *Pseudococcus citri*, the other a large, fleshy, pink scale of the subfamily Coccinæ, probably as yet undescribed. These coccids are carried by the ants into canals eaten out along the pith of the smaller new growth which will bear the next season's fruit. This growth is thus weakened to such an extent that when bent down by the pickers at the next harvest it breaks easily. In this way much fruit is lost. The pickers are considerably annoyed by the ants.

Considerable work has been done with tanglefoot, repellents, and poisons, but nothing satisfactory has yet been found. It appears that a native ant, called "albayalde," when present naturally or when introduced, drives the coffee ants away, killing many and occupying their nests. These ants might possibly be used as an aid in fighting the coffee ants, but the pickers consider them far worse than the coffee pests, for their sting is quite painful.

The coffee leaf-miner (*Leucoptera coffeella*) is abundant throughout the island, and though its two chalcid parasites are everywhere present they seem to be numerous enough to check this pest only locally, and no effective method of treatment has been found.

A lepidopterous borer, determined by Dr. H. G. Dyar as *Psychonotua* sp., which was reported by Tower in 1908[1] as boring in orange, citron, rose apple, and sweet almond, has done considerable damage in certain sections, where the trunks and larger branches of the coffee plants are riddled with canals. When the damage is slight the larvæ may be killed by running a wire up the canals; later, when the canals are longer and shrubs are so riddled as in some places, the only safe method is to cut down and burn the trees and allow new growth to come up.

The coffee weevils are confined to certain hill districts, where they cause considerable injury. The eggs are laid between leaves, the larvæ descend and feed on the roots, and the adults feed on the leaves at the time when the plant is fruiting, thereby weakening it when strength is most needed.

The larvæ of one of the May beetles, or "caculos," is commonly found at the roots of coffee in the hill districts, and the adults feed on its leaves. In the western end of the island, at least, the adults are parasitized by a tachinid (*Cryptomeigenia* sp.), which in some cases is apparently an effective check. Work is now under way to learn if it is practical or advisable to propagate and distribute these parasites to coffee and sugar-cane plantations where the May beetles are troublesome.

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[1] Porto Rico Sta. Rpt. 1908, p. 27.

FRUIT FLIES.

A fruit fly (*Anastrepha* sp.),[1] closely related to *A. acidusa*, breeds so commonly in one of the native mangoes (mangó de puerco) that it is difficult to get a good fruit from some trees. It also attacks some of the introduced Indian species, as the Cambodiana, 2 to 15 larvæ being found in a single fruit. It breeds freely in guava, jobo amarillo, and jobo de la India fruit as well, and as fruit is present on some of these trees the year round it is possible that this fly may breed throughout the year.

The lechosa fruit fly (*Toxotrypana curvicauda*) is abundant at Mayaguez and has been reported from St. Johns, Antigua, West Indies; Brazil, Peru, and Yucatan. The adult is a large bright yellow fly with black markings, yellowish transparent wings, and a long—14 millimeters—curved ovipositor. The eggs are laid well below the surface of the green fruit; 2 to 15 or more larvæ mature within the fruit, and when it drops pupate 1 or 2 inches below the surface of the ground immediately below the fruit. Adults emerge in 17 to 21 days, and eggs for another brood are soon laid.

Spraying with sweetened arsenate of lead and daily destroying the drops should soon control the lechosa fruit fly, though the adults are strong fliers. There is, however, little hope of checking the mango fruit fly, for its hosts grow wild in most parts of the island, and its parasites apparently attack it only in the jobo fruit. The larvæ in jobo are commonly attacked by two hymenopterous parasites, *Opius* (*Utetes*) *anastrephæ* n. sp., and *Ganaspis* n. sp.[2]

MAY BEETLES, OR CACULOS.

Some work has been done with the common May beetles, or caculos, whose larvæ attack the roots of sugar cane, coffee, citrus trees, pineapple, and aguacate. The adults, emerging from the ground at the base of the tree at night, feed on the newer leaves, frequently causing considerable injury. Various experiments with insecticides are now under way. The Japanese beetle fungus (*Metarrhizium anisoplioe*), which was introduced by this station some time ago from Hawaii, has been propagated and distributed with directions for use, the following method of growing on yam or sweet potato being recommended. It has been recovered from sections at some distance from where it is known to have been distributed, and is apparently spreading as rapidly as could be expected, but just how effective it is can not be determined for some time.

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[1] This was first determined by W. R. Walton as *A. acidusa*, but comparison by Dr. L. O. Howard with the type of this species in the British Museum shows that the mango fruit fly is a different species, possibly undescribed. However, "Mr. Knab is now inclined to think that the species is *A. fraterculus*," which has been recorded from Brazil, Peru, Colombia, Yucatan (Mexico), Cuba, and Porto Rico.

[2] The species of Opius was described by H. L. Viereck, of the United States Depatment of Agriculture, Bureau of Entomology, and the Ganaspis was determined by J. C. Crawford, of the United States National Museum, Division of Insects.

DIRECTIONS FOR PROPAGATION OF THE CANE BEETLE FUNGUS BY THE PLANTERS.

Take a medium-sized yam or sweet potato (¼ to ½ pound), wash carefully, pare, and cut into sections 1 inch long by one-half inch thick. Cover these with water and boil for 20 minutes in a covered dish, then turn off all the water and set to one side to cool, being careful to replace the cover that no other fungi may enter. As soon as this media is partly cooled, yet somewhat warm, remove the squares of beetle fungus from the tubes and rub them over the upper surfaces of the squares of yam, being careful that the spores are evenly distributed. Place the squares with the newly sown fungus in several large-mouthed glass jars or bottles which have been properly sterilized with hot water and cover with a piece of glass, also dipped in hot water, or if not available a cloth wrung out in boiling water. The cover should be tight to keep out any other fungi or small flies which would otherwise breed in the media. By the second day a white growth should appear over the surface of the squares, and by the fourth or fifth day this should begin to turn to a greenish color due to the presence of spores. The time required for sporing varies considerably, but one or two weeks is usually sufficient. The jars should be kept away from the direct sunlight and good results have been obtained by keeping them in the dark a part of the time. As soon as the fungus has become a dark green color it is ready to use. Place several inches of earth in a box with a tight covering of wire or cloth, plant two or three pieces of cane with tender leaves for the beetles to eat, and mix several squares of the fungus in the earth. Collect a number of the cane beetles and, after rubbing some of the fungus over their bodies, place them in the cage for several days. The earth should be kept moist but not muddy, as the fungus will not work under these conditions. By examining the material in the box every few days you will soon find that a number of the beetles have died and that their bodies are covered with the fungus. The remaining live beetles should now be freed in the field to carry the disease through the cane fields or citrus orchards, while the dead ones and other squares of beetle fungus should be scattered through the fields mixed with earth at the base of the cane or trees. A cage once infested will remain effective for months and may be used for many lots of beetles, but the cane may need to be replaced to keep the leaves fresh.

BENEFICIAL INSECTS.

A colony of ladybirds (*Cryptolœmus montrouzieri*) was secured from the Sugar Growers' Experiment Station at Rio Piedras, and as these increased several hundred have been distributed to sugar and pineapple growers, in whose fields they should be effective aids in controlling the mealy bug (*Pseudococcus citri*).

A colony of aphis-feeding ladybirds (*Hippodamia convergens*) was introduced from California and freed at various points in Mayaguez, where aphids were abundant. As the aphids are usually held in check by the rains, syrphid flies, hymenopterous parasites, and three native ladybirds, this new introduction is not a necessity, but may prove useful, as it breeds rapidly.

BEES.

Beekeeping is now an industry of considerable importance in Porto Rico, and efforts have been made to encourage its growth. Experiments made with cement for hives and stands promise good results, but it is a new field, and just how far it can be used needs to be determined. In Porto Rico the stands, bases, and brood chamber often decay in a short time. These three parts can be made of cement at an equal or less cost than the wooden ones now in use, and not only last longer, but keep the brood chamber several degrees cooler.

A bee census of the island is now under way, and with this fuller information as to conditions the station should be better able to help the bee growers. For the past year the weight of two hives has been taken regularly night and morning to determine the amount of honey stored by a single swarm. One 10-frame hive with 4 supers made 357 pounds; a second, with 2 supers, made 539 pounds. The largest amount stored in one day by a single hive was 12 pounds. The average for one swarm was 1.48 pounds, and for another slightly less than a pound. The last half of the past year has been unsatisfactory to many apiarists, for heavy rains, whenever there was a good bloom of guamá or the other principal bee flowers, washed out most of the nectar, and the bees have been able to make little more than half the usual amount of honey.

REPORT OF THE ANIMAL HUSBANDMAN.

By E. G. Ritzman.

The general character of the work during the past year has been along lines similar to those of the preceding year, though with somewhat more attention to forage-crop production. A large part of the time was necessarily spent in work of routine character which is augmented at certain seasons by unfavorable conditions that affect the health and development of live stock in this locality.

During the year the station lost its entire herd of hogs, including 15 head of Berkshires, from an infectious disease. No definite knowledge was obtained as to the nature of the disease, as post-mortem examinations[1] made on various animals showed lesions of hog cholera, swine plague, and swine erysipelas.

HORSES.

The cooperative work in horse breeding between the station and various breeders has shown good results (Pl. IV, fig. 2). Of the progeny resulting from the American saddle-bred stallion during this time there are 26 from last year's crop and 16 in this year's crop. In all cases there is evident a remarkable prepotency of the sire. In color all his progeny is either black or bay. The yearlings are around 13½ to 14 hands, possess a good carriage, and when well filled out will make a nice type of horse. There are 22 colts, all in this year's crop, sired by the 2 thoroughbred stallions, 15 by the bay and 7 by the chestnut. The value of an occasional cross with thoroughbred blood is well shown in these colts. They are large, deep chested, and well muscled, and possess well-shaped legs and feet, with hard bone. With the type of mares available here as foundation stock it will probably prove safer to obtain size by making the first cross with thoroughbred blood, as the native horses have similar ancestral lines, and then proceed with any other blood necessary to obtain the object desired in conformation and action.

During the last year a number of standard-bred trotters (three mares and three stallions) have also been introduced here, and their hardiness to resist local conditions so far have won them much favor. One of the stallions has sired 27 colts in this year's crop. They are a promising lot of young animals, but conclusions regarding their comparative value can not be drawn at present, as results in such work are necessarily slow. Some Morgan stallions have also been brought in during the past few years, but no record of their service has been obtained by this station as yet. A registered Morgan colt, Edmunds (Am. Morgan Register No. 6581), by General Gates No. 666, was obtained by the station through transfer from the Bureau of Animal Industry, and a 3-year-old American saddle-bred stallion (Black Badger No. 4213) was purchased in San Antonio, Tex. Both of these animals are good individuals with good ancestral lines of their respective breeds, and should contribute considerable benefit to the horse-breeding industry of the island.

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[1] The post-mortem examinations were made by Dr. Clark Hartman, veterinarian of the sanitation department of the island.

CATTLE.

The cooperative work between the station and some of the cattle breeders on the south side of the island in producing a more useful work ox, as mentioned in the last report, is now in its second year of progress. The bulls used in this work, as previously stated, are cross-bred Zebu with Shorthorn and Zebu with Hereford. Two crops of calves have been sired. Of the first, or 1911, there are between 100 and 125 calves, and of the 1912 crop there are 132 calves by these bulls and from native cows.

Measured by standards of comparison there is little doubt as to the value of this cross. One lot of 62 of these calves, dropped about a year ago, now weigh between 600 and 700 pounds each, while calves in the same herd and of the same age, but by native bulls, weigh around 400 pounds each. There exists among breeders here a strong color prejudice in favor of the red. The calves from this cross present a great variety of color and color mixtures, which militates somewhat against the favor they justly deserve for their other good qualities.

The progress of developing a station dairy herd is going forward slowly. The half-bred Shorthorn heifers which are of breeding age are bred to Shorthorn bulls, and the Guernsey bull is used for crossing with native cows. The station now has five half-bred Shorthorn cows and heifers on native foundation and one three-quarters bred Shorthorn on native foundation. Some of the half-bred animals keep free from ticks, while some carry a considerable number when exposed to infestation, but in all cases under observation so far those having a long coat of hair carry a large number of ticks, and those with short smooth coats are free from ticks.

Unfortunately, nearly all the calves which have been sired by the Guernsey bull so far were males, and were therefore sold to the butcher. The service of these bulls has been offered to planters in the neighborhood, and will, no doubt, be of benefit. Thirty-seven cows have thus far been brought to the station and bred to the Guernsey, 11 to the Jersey, and 4 to the Shorthorn bull.

DAIRYING.

The general agitation for pure wholesome milk has made itself felt on the island during the past year. The first step in this direction is retailing milk in a standard bottle with caps. Evidence of a desire for better milk is given by the strong demand for milk of the Ponce Sanitary Milk Co. and the milk sold by the station, both of which retail at from 2 to 6 cents higher per quart than milk from other sources, depending on the locality and season.

Owing to the excessively high price of milk and dairy products it is possible here to make a small margin of profit on cows that would be milked at a loss in the States. This no doubt accounts partly for the continuation of lax dairy methods, among which the partial milking of the cow with a calf is foremost. As native cows are of a rather nervous temperament it seems, in most cases, impossible to milk them without starting the milk flow with a calf if they have become accustomed to that method. This practice not only shortens the period of lactation, but the cows give less milk daily under this method than when milked without the calf. It is not uncommon that calves will refuse to suck the cow after 6 months of age, in which case the cow goes dry. A similar bad effect results from the custom, which is not uncommon, of milking only once a day.

The station dairy during the past year consisted of six cows. Three of these were broken to the native method of milking and three were milked without being started by the calf. Of the cows that had to be milked with calf to start the milk, one, a half Hereford half native, and the other two, which were pure native, gave 5 quarts when in full flow. The lactation period of these cows was, respectively, seven and a half and eight months. As the period of lactation advanced a decrease in quantity was shown in the pail, while a relatively larger proportion was consumed by the calf. The maximum amount obtained from any one of these cows was not over 1,800 pounds per year. Of the cows milked without a calf, one, a half Shorthorn half native, completed five months of her lactation period with nearly 2,000 pounds. A pure-bred native cow which has just calved gives 21 pounds daily, and a pure-bred Jersey has just completed a lactation period with 3,978 pounds. Near cities, where good milk sells at 10 cents or over, it is a losing proposition to conduct a dairy in which cows have to be milked partially by calves. At these prices of milk the calf costs approximately 25 cents a day, or in the neighborhood of $60 at the end of an eight-months' lactation. As such calves can be purchased at that age for $20 or less there is a clear loss of at least $40 per cow.

As the station has had no laboratory in which to conduct investigations on the composition of milk, no tests have been made here; but an inspection of the records of the Ponce Sanitary Milk Co. showed that native cows yield milk which is as rich in butter fat as average dairies in the North. Some herds tested almost 6 per cent during March, one herd of over 50 cows tested over 6 per cent, and none at that time tested much below 4 per cent. As the patrons are paid by test, these data should be very reliable.

POULTRY.

The demand for poultry and eggs for breeding purposes is very brisk during the more favorable hatching season, from the beginning of December to about the 1st of April or May, depending on the weather conditions. There was a decrease in the sale of both fowls and eggs from previous years, due probably to the increase in number of private breeders who are engaged in this business. One trio of White Orpingtons was added to the flock during the year.

Some modern poultry plants have been established in the vicinity of San Juan. The results obtained at these farms warrant the statement that poultry can be grown as well here as in the North, and, further, that the losses need not be greater if the fowls are properly handled. The use of the hot-air brooder has no doubt contributed largely to the success of these enterprises, since by means of it chicks are forced through the first six or eight weeks much more rapidly than would otherwise be possible. The hot-air brooder gives an even temperature which, connected with the proper kind of food and sanitary conditions, brings these chicks to a larger size and makes them hardier, stronger, and better feathered at the end of this time, while chicks grown without the brooders are usually smaller, weaker, half-naked, and therefore much more subject to disease, especially sorehead and catarrh.

A number of remedies have been tried at the station for sorehead, such as carbolic acid, tincture of iodin, copper sulphate, potassium permanganate, creolin, and corrosive sublimate, but no results of value have been obtained when applied in very dilute solutions, as usually prescribed. The only decided success has resulted from undiluted creolin very carefully applied on the scabs with a feather and then washed with water after the scab is dry. This seemes very severe treatment, but no injury resulted from its use, and birds so treated were saved, whereas others in equally advanced stages treated with tincture of iodin and carbolic acid died.

FORAGE CROPS.

The introduction of a larger variety of forage crops is a very important factor in the live-stock development of the island. The introductions tried up to the present time consist of corn, sorghum, both saccharine and nonsaccharine, grasses, and legumes. Of the 20 varieties of corn, 12 have been obtained from Mexico, 2 from Brazil, and 6 from the States. Unfortunately, they were mostly destroyed by rats, some either before or after sprouting and the rest when the seed had formed but was still too immature to harvest. Up to the present time about 24 or more varieties of sorghum have been tried. Of these, 16 are of African origin furnished by the Bureau of Plant Industry, 1, commonly known as Guinea corn, was obtained from Barbados, 2 are from Mexico, 2 from Cuba, and the rest from the States. Of the African varieties only one has been preserved (B. P. I. No. 25341), being the most promising. It matures in 100 days under favorable conditions. The forage from a plat of this weighed 30 tons per acre. It has a thick stock, dense leaf development, dense seed head, and a peculiar sweet aroma. Cattle seemed to like it quite well. The Barbados variety, described in the last report, has given a very heavy crop again this year. The Cuban and Mexican varieties were destroyed by rats. The varieties from the States were planted during the dry weather and had therefore a poor start. Jerusalem corn yielded only 3 tons per acre. A plat of Improved Evergreen broom corn yielded somewhat less. Early Orange sorghum produced 11 tons per acre. Of these only the latter seems worthy of further trial. A small plat of teosinte has also been planted but has not come in seed yet.

A plat of Golden Tankard mangels was planted this year, but owing to a low percentage of viability only a few seed sprouted. The few roots that grew to maturity were very small, not more than one-quarter the size they naturally attain. Some white turnips and pumpkins have been grown successfully in the past. Native root crops, such as yams and yautias, have been successfully grown at the station,[1] but their culture for stock is of questionable value, owing to their starchy composition and their slowness in maturing. A few plats of rape were grown and fed to sheep. This should make a valuable feed when grown in small patches for sheep, goats, and pigs.

A few new grasses, *Paspalum dilatatum*, and Rhodes grass, were reported on last year. Nearly two years' trial shows that both will do well in lowland. Rhodes grass has held its own against malojilla whereas Paspalum is being partly crowded out by it. On high lands, in clay soils of poor mechanical condition, Rhodes grass was killed out by drought while Paspalum still retains a hold. A considerable number of samples of these two grasses have been sent out over the island and they will therefore get trials under the varying conditions of soil and moisture.

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[1] See Report of Horticulturist, p. 26.

During the year brown teff (*Eragrostis abysinica*) and molasses grass (*Melinis minutiflora*) were added. The former is a sort of wire grass which grows very rapidly, produces an abundance of seed, but does not grow very high or produce much leaf. Molasses grass propagates itself from runners the same as malojilla. In lowlands it grows much thicker with a heavier leaf development than malojilla. It has a very strong aroma, which probably has given it its name. It is the most productive grass tried here so far on lowland. None has yet been fed, but in Brazil, its habitat, it is given first place among grasses.

Pearl millet has made a splendid growth here, producing over 14 tons of forage per acre. Hairy vetch (*Vicia villosa*), which was given a trial, proved a failure, being of too delicate growth to contend with malojilla and the more common weeds.

Alfalfa, sweet clover, and crimson clover were also tried out during the year. Notwithstanding the extremely wet weather, the alfalfa has made good growth on lowland soils limed at the rate of 1,500 pounds per acre. Unlimed plats made a good start, but died out within six months. The limed plats have grown to about 2 feet in height. The first crop, about three months after seeding, yielded at the rate of 4 tons. After this was cut it was again limed at the rate of 1,200 pounds per acre, and the next cutting, made in three months, yielded at the rate of 6 tons per acre. Crimson clover sowed at the same time made not over 3 inches growth and died out within four months after seeding. Sweet clover was not given a fair trial, as the seed was applied too thin, but the indications are that it is worth the effort of further trials.

Among other legumes is a Stizolobium bean which has produced an immense crop of fodder. It grows in long vines 20 to 30 feet long, produces an abundance of leaves, but is very slow to mature seed. Plats of cowpeas, sword beans, and soy beans have also been planted this year with similar results as before. The seed harvested from half a plat of cowpeas (New Era) weighed 45 pounds, or at the rate of about 1,800 pounds (30 bushels) per acre. Sword beans also grow well, but soy beans have proved a failure in two attempts to grow them.

A lack of analyses of fodder crops grown in Porto Rico somewhat hinders obtaining a true estimate of their nutritive value.

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PORTO RICO AGRICULTURAL EXPERIMENT STATION,

D. W. MAY, Special Agent in Charge.

ANNUAL REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION FOR 1913.

UNDER THE SUPERVISION OF
OFFICE OF EXPERIMENT STATIONS,
U. S. DEPARTMENT OF AGRICULTURE.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1914.

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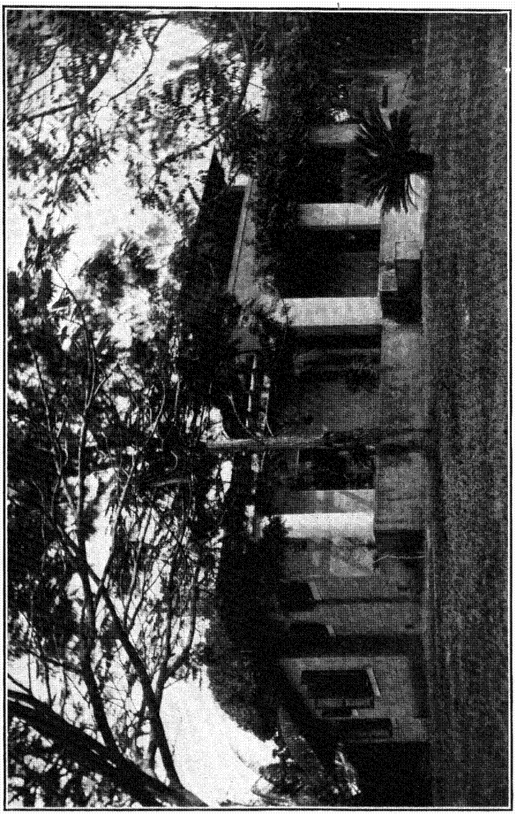

RESIDENCE OF SPECIAL AGENT IN CHARGE.

Issued May 28, 1914.

PORTO RICO AGRICULTURAL EXPERIMENT STATION,

D. W. MAY, Special Agent in Charge.

ANNUAL REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION FOR 1913.

UNDER THE SUPERVISION OF
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WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1914.

PORTO RICO AGRICULTURAL EXPERIMENT STATION.

[Under the supervision of A. C. TRUE, Director of the Office of Experiment Stations, United States Department of Agriculture.]

WALTER H. EVANS, *Chief of Division of Insular Stations, Office of Experiment Stations.*

STATION STAFF.

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G. L. FAWCETT, *Plant Pathologist.*
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R. H. VAN ZWALUWENBURG, *Entomologist.*
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C. N. AGETON, *Assistant Chemist.*
W. E. HESS, *Plant Propagator.*
C. ALEMAR, Jr., *Clerk.*

LETTER OF TRANSMITTAL.

Porto Rico Agricultural Experiment Station,
Mayaguez, P. R., November 15, 1913.

Sir: I have the honor to transmit herewith and to recommend for publication the Annual Report of the Porto Rico Agricultural Experiment Station for the fiscal year ended June 30, 1913.

Respectfully,

D. W. May,
Special Agent in Charge.

Dr. A. C. True,
Director Office of Experiment Stations,
United States Department of Agriculture,
Washington, D. C.

Publication recommended.
A. C. True, *Director.*

Publication authorized.
D. F. Houston,
Secretary of Agriculture.

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ANNUAL REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION FOR 1913.

SUMMARY OF INVESTIGATIONS.

By D. W. MAY, *Special Agent in Charge.*

INTRODUCTION.

There was further progress in agriculture in Porto Rico during the fiscal year 1913, but with the shifting of certain lines. These changes have been in the way of greater diversification and therefore wise. The total value of exports was $49,103,565.

SUGAR.

Sugar still holds first place in the industries of the island, the exports for the year having a total value of $27,226,905. There has been great uncertainty in this industry because of the reduction of the tariff, which will lead in a few years to free sugar and open competition of Porto Rico with the whole world, but the planters and mills have in a measure prepared for this. The growers have in many cases introduced improved varieties of cane, while the fertilization and cultivation of the crop has been vastly improved. On the other hand, lands not well suited to the crop have been planted and others have been continuously planted to cane, so that yields have been reduced to a minimum. Many of these lands will now go out of cultivation. A period of retrenchment is ahead for the sugar industry, and especially for those who have burdened themselves with debt or with contracts made under former conditions. Extreme economy and efficiency must be practised.

TOBACCO.

Tobacco, especially its manufactured products, makes the second largest item of export. The value of the manufactured tobacco amounted to $5,824,030, unmanufactured $3,188,227. There was imported unmanufactured tobacco to the value of $373,975. Porto Rican tobacco is being improved in quality, finding a larger market, and increasing in price. There is a large population skilled in certain lines of tobacco manufacture, as cigar making.

COFFEE.

The value of the exports of coffee for the year amounted to $8,511,316, by far the largest amount since the American occupation. The coffee industry is showing commendable progress. This is due to better cultivation and higher prices. Planters, too, are following better practices in the selection of seed for planting. The station has introduced and grown for distribution Java and other coffees that are yielding better than native coffee and giving a higher percentage of large and uniform grains. This is giving results not only in greater yields but in better prices.

Associations and individuals are striving to obtain better markets and to gain and to hold a higher reputation for Porto Rican coffee. The industry is on a better footing than it has been for years and that, too, without the benefit of tariff or bounties but in competition with the whole world.

Of the coffee exported during the year $8,378,346 worth went to foreign countries, while only $132,970 worth went to the United States. The coffee is following the old lines of trade established by tariff laws during the Spanish régime. It is a product whose trade is established upon the preference of taste and is therefore a most difficult one to change. A flavor, a very evanescent thing in a food product, is yet one of the most valuable and one for which the demand is most persistent. To obtain a market for Porto Rican coffee in the United States the preference of a great many people must be changed. The cost is too great to justify this as long as the foreign market demands the Porto Rican product and places it at the top of the price list of coffees from all over the world.

FRUIT.

The fruit industry shows the most phenomenal increase of any line in Porto Rico. During the year $2,767,027 worth was exported, of which $151,681 was canned pineapples. The value of pineapples exported as fresh fruit amounted to $1,142,007; oranges, $740,010; and grapefruit, $726,687.

This is an industry that started from nothing 10 years ago, and as trees already planted come into bearing is sure to increase to a much greater extent. It represents the highest type of intensive farming and is most promising in Porto Rico. To the man with perseverance, industry, and personal supervision it promises good returns. Porto Rico is safe from frosts that threaten the industry on the mainland and is at the open door of the best market in the world—New York and the eastern seaboard.

There has been established a cooperative fruit exchange, which is proving of great benefit to the growers. In the third year of its existence just closed sales through the exchange amounted to

$568,887. The commission rate before the formation of the exchange was 8 to 10 per cent; the average rate of the exchange has been 6 per cent. Of the capital stock 40 per cent has been paid in cash and 36 per cent more out of the dividends on earnings. After paying 12 per cent annually on the capital stock 75 per cent of the net income is divided pro rata among the shippers, there being now 101 under contract with the association.

Besides selling fruit the exchange imports and sells to members packing boxes and fertilizers, thereby effecting a saving and giving favorable terms of payment. An office is maintained in San Juan, P. R., and in New York City.

The exchange has also resulted in great benefit by bringing the planters into closer cooperation, by inspecting fruit offered for shipment to see that it is ripe and properly packed, and that it is carefully handled in shipping. The greatest good of all, however, has been in bringing allied interests together for mutual good not only in material receipts but in comparing and testing individual results in order to apply them for the good of all.

COCONUTS.

The value of exports of coconuts for the year amounted to $352,390. There is considerable planting of coconuts on the island and there are considerable areas yet where these trees may be profitably set. A coconut grove properly cared for yields a sure and steady income. Better cultivation, the growing of legumes among the trees, the utilization of seaweed and other manures, yield excellent additional returns over cost.

The station has under trial a number of other nut-bearing trees, both edible and oil bearing. Doubtless some will prove profitable for cultivation on the island.

LIVE STOCK.

Animals are no longer exported from Porto Rico, but are insufficient for home needs. Besides breeding stock, large amounts of meat and meat products are imported annually. The consumption of meat has increased with more prosperous times. The amount of local production consumed is indicated by the exports of $187,013 worth of animal by-products—hides, skins, and tallow.

MISCELLANEOUS.

Of the minor industries which the station has tried to foster honey production has done well. Since the establishment of the apiary at the station and the teaching of beekeeping in short practical courses apiaries have been placed in many sections of Porto Rico. Honey exports during the year had an aggregate value of $69,235. No serious bee diseases exist, and with the inspection law and vigorous quarantine they should be kept out.

Now that sugar is expected to go on the free list in a few years it behooves planters to study diversified farming more than they have ever done before. There is very little unproductive land in Porto Rico and the range of products in such a soil and climate is wide. Every soil here is adapted to the profitable production of some crop. It is the station's business to find the best crop for the different soils and situations.

Besides the various lines of work reported under separate heads, the station has a number of cooperative projects under way. These are conducted with various planters in trials of forage crops, such as alfalfa and introduced grasses; with live-stock breeders in the loan of pure-bred sires; with citrus growers in fertilizer tests in orange groves; with the insular government in planting sisal on dry stony land of the south side; and with the insular fair in getting together exhibits, superintending them, and judging awards.

The agriculturist in Porto Rico is very much handicapped by lack of credit. This is due partly to inheritance of customs and partly to cumbersome and expensive land laws. The legal rate of interest in Porto Rico is 12 per cent per annum and the small holder can not borrow money for less than this rate. In some cases, where he assigns his crop to a mill or commission house, he can borrow money at 8 per cent, but in doing so he ties his hands as regards the sale of his products. The mortgage laws are not bad in themselves. In one respect they are very commendable in that a mortgage can be given to secure a note which is transferable, giving it, therefore, the element of convertibility, and passes readily from hand to hand, but when it comes to notarial fees and the cost of registration the sums are so excessive as to be prohibitive for small loans. This is partly due to the inheritance of old Spanish laws and customs whereby the transfer of land was largely in the hands of the notaries and they and the registrars of property had a very elaborate system of fees that were excessive. Some laws looking to the quieting of titles and the easy registration of evidences of ownership would be highly desirable. The Torrens law, which has worked so well in the Philippines, could doubtless be adapted to the conditions in Porto Rico with great benefit.

During the year a new residence for the special agent in charge was completed (frontispiece), and work was begun on a plant laboratory building that will be better suited to the station's needs than the present propagating house (Pl. I, fig. 1). Both structures were provided for out of funds appropriated by the insular government.

REPORT OF THE CHEMIST AND ASSISTANT CHEMIST.

By P. L. Gile and C. N. Ageton.

INTRODUCTION.

The character of the work the past year was the same as in previous years, attention being directed to soils and studies in plant nutrition. Two investigations begun several years ago were completed and progress was made in others still under way. At the last insular legislature an appropriation was made for a plant laboratory for the experiment station. The appropriation will cover the construction and equipment necessary for conducting vegetative experiments in pots on a good scale. This increased equipment should make it possible to extend the scope of the work considerably along some lines.

The cooperative field experiments were considerably increased last year. In the Anasco Valley 35 acres more were laid off in plats on property belonging to the Guanica Centrale. There are now about 140 plats under observation. With the other work under way it is hardly possible to attend to any more plats at present, but it is along the lines of increased field experimentation that the work could be most practically extended.

NEED FOR A SOIL SURVEY COMBINED WITH FIELD EXPERIMENTS.

To secure a knowledge of the fertilizer and general requirements of all the different soil types on the island will require a tremendous number of field experiments because of the great variety of soils and climatic conditions. An attempt is being made to accumulate such a knowledge of all the soil types, but without special provision for comprehensive work it will take a long time. A soil survey of the island should be made, mapping the areas of the different soil types, and along with the soil survey a series of field experiments should be conducted to determine the fertilizer, lime, and other requirements of the different types of soil in the different climatic localities.

Such an undertaking would necessitate a special appropriation, as it would require the time of another man and involve considerable expenditures for fertilizer and travel. It would, however, be especially valuable. That there is need for such a comprehensive series of field experiments is well shown by the number of soil samples sent to the station with requests for advice as to their fertilizer requirements, etc. Also, the fact that some of the larger agricultural concerns have appointed men to conduct field experiments on their different properties shows that this need for a more definite knowledge of their soil requirements has been appreciated. Of course, a definite knowledge of the requirements of the different soils can only come from definite field experiments. Short methods of determining soil requirements by chemical analysis of the soil, chemical analysis of the crop, or by vegetative experiments in pots, are not reliable when translated to field conditions except in special cases.

At the present time a large amount of money is being lost by using fertilizers where they do not yield an adequate return, and by failure to use them where they would do so. Except in places where direct experiments have been carried on, the use of fertilizers is governed very largely by the selling abilities of the agents of the various brands. Any money spent in learning simply the fertilizer requirements of the various soils would be well invested. Where one corporation is buying $50,000 worth of fertilizer a year, a 10 per cent increase in the efficiency of the use of the fertilizer would mean a saving of $5,000.

It is to be hoped that funds may be secured for undertaking a comprehensive system of field experiments in connection with a soil survey.

ANALYTICAL WORK.

The analytical work this year has consisted in the analysis of 235 samples of soils, plant ashes, waters, yams, limestones, guanos, fertilizers, molasses, and some miscellaneous materials. Most of the work was done in connection with the investigations noted in the following pages.

Thirty samples of yams, however, were analyzed for the horticultural department, and for the plant pathologist various tannin and nitrogen determinations were made.

THE RED-CLAY SOIL OF PORTO RICO.

A report on the red-clay soil has been prepared for publication.[1] This embodies results to date, but does not close the work on this type of soil. The old fertilizer plats at Anasco are being continued, and about 35 acres of new plats have been laid out on another field. The old plats with the ratoon cane will be cut in January, 1914. The appearance of these to date supports the previous results with plant cane in showing that nitrogen is the most essential element for sugar cane on this soil. Also, the beneficial effect of the heavier liming in 1911 is noticeable in the appearance of the ratoon crop.

The new plats, 68 in number, are one-half acre each. They are designed to further test the fertilizer results obtained on this soil and to determine more accurately, if possible, the profit or loss resulting from applications of different fertilizers and lime. In these plats a comparison of nitrate of soda, sulphate of ammonia, and dried blood is being made to determine which form of nitrogen on this soil is most effective for sugar cane. Each plat is repeated six times, so the results should be definite for the year and soil.

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[1] Porto Rico Sta. Bul. 14.

CHLOROSIS OF SUGAR CANE.

In 1911 a field experiment was begun at Central Cortada for studying the effect of different methods of applying iron to the chlorotic cane. The plats were cut by mistake before the weights could be obtained, but their appearance before cutting seemed to show that stable manure, stable manure mixed with ferrous sulphate, and spraying with a solution of ferrous sulphate were beneficial, while a simple application of ferrous sulphate to the soil had no effect. The new plats, planned along the lines of the old ones, but on a larger scale, will be cut the first of next year.

The soil samples, taken in the course of the soil survey of the chlorotic areas, have been analyzed for the water-soluble constituents as well as for the acid-soluble. One sample from a chlorotic area at Central Cortada, Santa Isabel, carried nearly 0.2 per cent of water-soluble salts, calculated as sulphates, but contained no normal carbonates. The other samples from chlorotic areas were perfectly normal in their content of soluble salts, corresponding with the check samples from green areas. It is, therefore, evident that the chlorosis is not caused by accumulation of alkali salts in areas of calcareous soil.

Samples of green and chlorotic leaves of the same age have also been prepared for analysis. This work on the ash constituents of the leaves will be carried on next year, analyzing the leaves at different stages of maturity of the cane.

Two crops of chlorotic cane have now been under observation, and certain facts regarding the occurrence of the chlorosis have become apparent. There does not seem to be any definite period in the growth of the cane when it becomes chlorotic. Sometimes cane which has just sprouted is blanched, and at other times the cane is unaffected until it is eight months old. As a rule, ratoons seem to be affected more strongly and generally earlier than plant cane.

All stages of chlorosis have been observed—leaves entirely ivory white, some with only the midrib green, and others with the veins green but the parenchymous tissue colorless, giving a striated appearance. In some cases stools strongly affected with chlorosis die, while in others they become green and grow normally for a time.

The strongly calcareous cane soils and most of the areas of chlorotic cane that have been observed occur in the southern and southwestern parts of the island, where the rainfall is very irregular and the cane is grown by irrigation. In many cases the chlorotic cane is much improved after a rainy period; in others, however, the new leaves appearing directly after rains have been strongly chlorotic. From the observations thus far it appears very doubtful if the chlorosis is connected with the amount of water available, except that it may affect to a certain extent the factor which is causing the trouble.

It is believed that in some spots where the chlorosis occurs the condition of the cane would be much better if it were planted less deeply; if instead of embedding the seed in the marly subsoil it were planted in the richer surface soil. Of course, the deep planting is practiced on the theory that the cane will better withstand the drought.

As noted in the report for 1911, the areas of chlorotic cane are confined to strongly calcareous soil, but not all such produce chlorotic cane. Thus far it appears that there are some rather small areas that have been planted year after year that have always produced chlorotic cane. There are other fields where some chlorosis occurs every year, but the location varies somewhat with the year. Sometimes isolated stools are chlorotic, but in most cases the chlorosis occurs in definite areas, with the cane strongly affected in the center and partially affected at the edges. Many of the areas are on the slopes of the limestone hills.

BAT GUANOS.

But little progress has been made in determining the availability of the nitrogen and phosphoric acid in bat guanos by vegetative means, as the facilities have not been adequate for this work. When the new equipment for running pot experiments is installed, however, this work should go on rapidly.

Many guanos have been sent in from different parts of the island with requests for advice as to how they should be used. These have been tested by a rough quantitative method and the probable value of the material given.

EFFECT OF STRONGLY CALCAREOUS SOILS ON THE GROWTH AND COMPOSITION OF CERTAIN PLANTS.

This work, which was started some years ago, has now been completed as originally outlined. Besides pineapples, the study of which was reported in a bulletin of the station,[1] bush beans, radishes, sugar cane, sweet cassava, and rice have been grown on the plats. Each plant was grown six times, and samples of the various crops were analyzed for their mineral constituents.

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[1] Porto Rico Sta. Bul. 11.

The plants varied considerably with respect to the effect of carbonate of lime upon their growth. Bush beans, radishes, and sunflowers, were but little affected. Soy beans made slightly less growth on the calcareous soils than on the check soil. Sugar cane made a noticeably diminished growth in one plat only—that with 18 per cent of calcium carbonate. The growth of sweet cassava was slightly depressed in the plat with 5 per cent calcium carbonate and markedly depressed in the plats with 18 per cent and 35 per cent of calcium carbonate. Rice made a greatly diminished growth on all the plats containing carbonate of lime and was affected with the characteristic chlorosis on these soils.

Some plants showed quite a variation in their ash composition, induced by the carbonate of lime in the soil, while other plants had practically a constant ash composition, irrespective of the amount of lime in the soil in which they were grown. For instance, the extreme variation in the lime content of bush beans from the four different plats was only 3 per cent of the amount of lime present. These results would seem to show that, provided a soil is not absolutely deficient in calcium, it is futile to attempt to increase the lime content of certain fodders by liming the soil.

The detailed results of this work, which throw some light on the tolerance or intolerance of certain plants for calcareous soils, are being prepared for publication.

ACTION OF LIME IN INDUCING CHLOROSIS.

Supplementary to studies on the effect of strongly calcareous soils on the growth and composition of various plants, work has been carried on with those plants whose growth is strongly depressed on the calcareous soils to determine by direct experiments as well as by ash analyses how the carbonate of lime injuriously affects the mineral nutrition. Several experiments have been carried on with rice, which has been found almost as sensitive as pineapples to carbonate of lime. The experiments conducted with this plant have been on the following lines: On the effect of gypsum on the growth and composition of rice, the effect of carbonate of lime in depressing the availability or assimilation of iron, and the effect of spraying with ferrous sulphate on rice growing in a soil containing gypsum or carbonate of lime, and in their absence. A report on this work will probably be ready during the coming year.

ASSIMILATION OF IRON.

In the course of investigations with rice it has been noted that the iron content of the plant seems to vary considerably with different stages of growth. In order to trace the assimilation of iron, analyses are being made of a crop of rice at 30-day intervals.

REPORT OF THE HORTICULTURIST.

By C. F. Kinman.

The lines of work followed in the horticultural department were, for the most part, the same as those reported on formerly. With citrus fruits they included fertilization, stocks, and nursery problems. The vegetable work was confined to variety tests, cultural methods, and fertilizer requirements for yams, dasheens, yautías, and sweet potatoes, the testing of various introductions, and the continuation of experiments to determine the influence of Porto Rican conditions on a number of northern-grown vegetables. Several varieties of mangoes were imported during the year, some through the Office of Seed and Plant Introduction of the Bureau of Plant Industry, others from the bureau of agriculture of the Philippine Islands, and others from individuals in various parts of the West Indies. (Pl. II, fig. 1.) Work with this fruit included variety testing and propagation methods. Cooperative coconut fertilizer experiments were continued in old groves and plans were made for starting similar experiments in groves newly set. Numerous visits were made to various horticultural sections in response to requests from growers for conferences regarding horticultural problems.

CITRUS FRUITS.

While the cooperative fertilizer experiments with citrus fruits were practically closed a year ago, the plats in which the effect of muriate and sulphate of potash were being compared were continued in the grove near Bayamon. The results in this test were the same as in former years, no apparent differences having been observed resulting from the fertilizers either in the quantity or quality of the fruit or on the general development of the trees. From these experiments it seems that the general belief among Porto Rican growers that muriate of potash is injurious to citrus trees is not well founded.

During the past year the effect of fertilization on the citrus groves throughout the island was more noticeable than ever before. When heavy applications of complete fertilizer were given good crops of fruit were harvested with hardly an exception, and where small amounts or no fertilizer at all were applied the crop was very small. The results of fertilization were quickly shown on the general condition of the trees as well as the amount of the crop. Instances have

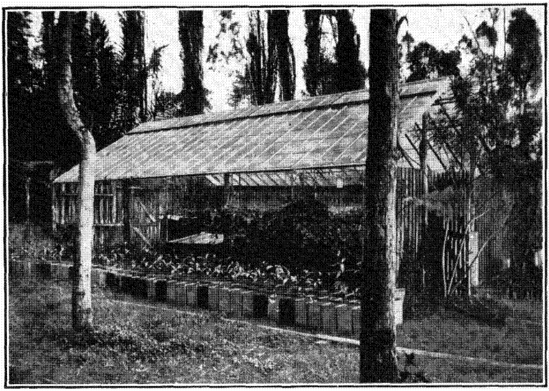

FIG. 1.—STATION PROPAGATING HOUSE.

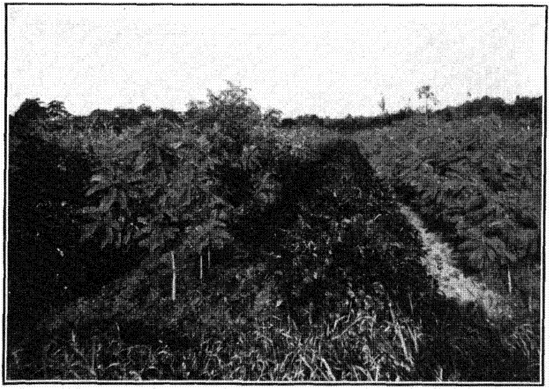

FIG. 2.—TRIAL PLATS, LEGUMINOUS PLANTS.

PLATE II.

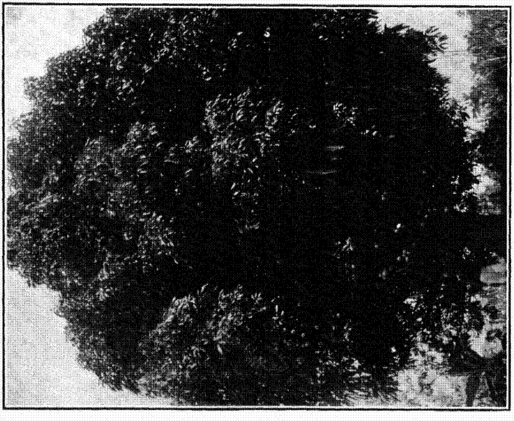

FIG. 1.—TOP-WORKED NATIVE MANGO TREE, VARIETY AMINI, IN FRUIT.

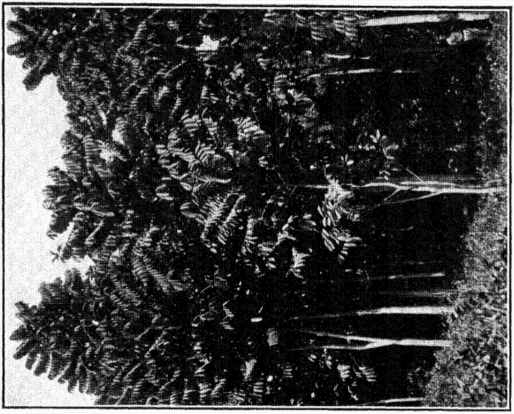

FIG. 2.—CASTILLA TREES 10 YEARS OLD.

been noted where one element was omitted in fertilizing and where little or none was given to trees which had in previous years been given sufficient nourishment to support a good crop of fruit. The result has been that the trees are producing small crops, many tips of the branches are dying, and the general condition of the grove is unsatisfactory. This would indicate that where such conditions prevail much of the available plant food has been used and the trees are now more or less dependent on the yearly application of fertilizer.

Applications of fertilizer both complete and incomplete were made in a number of localities and at different seasons relative to the rainy and dry periods in an attempt to influence the blossoming period of the trees. Citrus blossoms may be found any month of the year in Porto Rican groves, and as grapefruit always brings excellent prices during the summer months it is hoped that a method of fertilization may be found which will influence the fruit to ripen during the season of high prices.

As the prices of citrus nursery trees advances from year to year, and the demand is in excess of the supply, a trial nursery has been started to test conditions of the commercial nursery in this part of the island. Seed of well-matured rough lemon and native sour orange were planted during January, 1912, in small beds, where they could be watered, as the open field in this locality is too dry for young seedlings to thrive before May or June; and in June the seedlings were set in the nursery field in rows 3½ feet apart and 1 foot apart in the row. The field used for the nursery was a low heavy loam, which before planting was given an application of stable manure and a deep plowing. When set out the young seedlings were a few inches tall and in excellent condition for transplanting. During the summer months they grew slowly, due to excessive rains and heavy soil, but through the drier months they made a good growth. The lemon stocks grew faster than the orange and were ready for budding two months earlier. The lemon stocks were budded in May, 11 months after setting, and the grapefruit buds inserted made a good growth, by October being 3 to 4 feet long. The buds inserted into the orange stock have not grown so rapidly.

An application of complete fertilizer was given September 15, 1913, and the nursery has been cultivated a number of times, but aside from this the only attention given the seedlings was a little hand weeding in the row and the necessary pruning, all of the work being done by the ordinary laborers.

From this experience it seems that a nursery can be easily developed in this locality and at an exceedingly low cost; the chief requisites being a well-tilled and well-drained soil, which must be given sufficient fertilizer. For the western and southern parts of the island, which are subject to winter droughts, and on upland, where at least the surface drainage is good and the soil somewhat exhausted from continuous cropping, the lemon is, on account of its vigor, the most desirable stock. The sour orange, being more resistant to crown and root diseases, is better adapted to low or heavy or poorly drained locations.

GREEN-MANURE CROPS.

Experiments with leguminous green-manure and orchard cover crops were continued and a number of new varieties tested (Pl. I, fig. 2). Among the most promising of those not before reported on are a few varieties of Stizolobium sent for trial by the Office of Seed and Plant Introduction of the United States Department of Agriculture, including S. P. I. Nos. 24657, 32021, and 24424. These varieties, when planted during the dry winter season, produced a fair crop of seed, but made an unsatisfactory growth for a green manure crop. Where planted during the spring months excellent crops resulted. As these crops require several months for growing to maturity, it is desirable to plant them at the beginning or during the wet season and allow them to make a heavy growth, which will serve as a mulch during the dry season. These varieties compared with the common velvet bean and Lyon bean require a longer growing period and, at least on loamy soil, grow more rank. In the locality of Mayaguez these are desirable qualities, as the early maturing legumes allow grass and weeds to spread before the end of the rainy season, during which cultivation is undesirable. The velvet and Lyon beans have, however, proved to be excellent cover crops again this year. The velvet bean ripened seed earlier than the Lyon bean, the first seed to ripen being five months after planting, while the seed of the Lyon bean did not ripen until almost six months. The new introductions did not ripen for a much longer period.

As seed of any of these varieties are liable to decay if allowed to lie on the ground while ripening during a wet season, vines sufficient to produce seed for the succeeding planting should be planted near some other crop over which they can climb. A portion of the field planted thinly to pigeon peas makes an ideal crop for this purpose.

Four and a half months after planting, a cutting was made of a number of varieties of cover crops to determine the weight of the green vines. When freshly cut, it was estimated that the weight of the Lyon bean was 10.48 tons per acre, the velvet bean 10.78 tons, and S. P. I. No. 24657, 10.38 tons. After very thoroughly sun drying, the weight was 2.47 tons, 2.45 tons, and 1.66 tons, respectively. The heavier dry weight of the Lyon bean and velvet bean is accounted for by these being more mature and having formed seed pods.

As these crops are rank growing climbers, they are sometimes troublesome in groves as they climb over trees, but for a green manure in rotation with pineapples or on an otherwise unoccupied field they are an ideal crop.

During the past two years the sword bean and pigeon pea have been tested as nitrogenous manure crops and cover crops with pineapples by planting them in the pineapple beds. Four row banks of both Red Spanish and Cabezona varieties were used, two rows of the legumes being planted in each bank at the time of setting the pineapples, the number of leguminous plants being about equal to that of the pineapples. One portion of the field was left as a check. In one portion the legumes were cut and laid on the ground under the pineapple plants at the beginning of the dry season, about December, and not replanted until the first of the rainy season the following spring, and in the other portion they were replanted as soon as they matured seed, so there was a growing crop throughout the year. Where pigeon peas were allowed to grow throughout the year, the Cabezona variety made practically no growth, and where they were removed at the first of the dry weather, the pineapples made a poor development. The effect of the sword bean was much less marked up to the end of the first half year, the legumes seeming to have been a benefit to the pines. At the end of 18 months the injury caused by the legumes was very apparent, the pineapple plants being much more slender than the check plants.

The effect on the Red Spanish variety was less marked, though under all conditions injurious. At the end of the first year the sword beans seemed to have been a benefit to this variety and the pigeon peas but a slight injury, but by fruiting time the injury caused by both legumes was marked. Where the sword beans had been allowed to grow during the wet season only, the injury was the least, and most where the pigeon peas grew throughout the year. The pigeon peas were more injurious than the sword beans in every case.

COCONUTS.

The cooperative fertilizer experiment started in June, 1912, is being continued. During the past year four pickings of fruit were made, the last 16 months after the first application of fertilizer. Neither in the trees nor in the number or diameter of the nuts has the fertilizer thus far shown its effect. These results are to be expected, as old coconut trees seldom show any effect of fertilization under two and one-half years. As the grove in which this experiment is being conducted is situated on a typical Porto Rican coconut soil and due to age and close setting of the trees the crop of nuts is light, decisive results may be expected within a few years.

An examination in the experimental plats shows that the soil is a mixture of coral and silica sand with a small amount of humus near the surface. In the upper 6 inches of soil small fibrous roots are very numerous. From this depth to 16 inches there are many small and a few large roots. From 16 to 22 inches large roots are very numerous, and below this there are only occasional large roots going down to the water level, 3 to 5 feet below. Samples of soil were taken at a number of points in the coconut grove and at various depths, including some at sea level, for examination to determine the amount of salt in the soil water. No appreciable amount of salt was found except in borings within a few yards of the sea. As the samples were taken after several months of comparatively dry weather, it seems probable that salt is not carried far inland by underground seepage from the sea and is not so necessary for the development of coconuts as is sometimes thought.

While the land best suited to this crop in Porto Rico is taken up for the most part, there are still unplanted areas which would produce well, and as but little culture has been given to the groves there is opportunity for both extension and improvement of the industry.

DYNAMITE FOR LOOSENING SOILS.

Dynamite for loosening soil and facilitating drainage has been used in a number of places in Porto Rico, both in land devoted to citrus trees and to pineapples. While no experiments with it have been conducted on the station farm, observations were made in a number of places over the island where it has been tried. The principal use to which dynamite has been put in citrus lands during the past two years is in loosening the soil at the point where a citrus tree is to be set, for which purpose those who have used it claim it of benefit. Where it has been tried in old groves and in pineapple fields no improvement has been noted that can be attributed to it.

Where half-pound sticks were discharged three years ago 3 feet below the surface and 25 feet apart in an orchard of grapefruit which was several years old, no beneficial effects are yet apparent. In the part of this grove where the dynamite was tried the soil is sloping and in texture a heavy red sandy clay with a very heavy subsoil which drains poorly. This trial was made at a time when the surface soil was dry, though the subsoils of this type are always moist. Immediately after the discharges were made an examination showed that there had been formed a spherical opening about 1 foot in diameter at the point of the explosion the wall of which was broken by a network of cracks from one-eighth to three-eighths of an inch in width and the soil within several inches of the opening was packed much firmer than the surrounding soil. The cracks could be followed laterally from 2½ to 4 feet. About 3 square yards of soil above the charge was well loosened and raised a very few inches by the explosion.

Examinations have been made in this dynamited area a number of times, and the soil appears not to have drained any better, if as well, as has that near by. This condition might be expected, as the charges were placed so far apart that cracks caused by one explosion did not meet those of the next explosion, and the subsoil water could not drain from one loosened area to the next. It seems probable that the opening and cracks made by the explosion were filled with water during the rainy season, which, being held by the surrounding soil unbroken by the dynamite, left the water content highest at these places.

Where there is a substratum which can be broken through or the charges are placed so as to afford subsoil drainage from one loosened area to the other, dynamite should prove a very great benefit to our heavy soils, as poor subsoil drainage is one of the greatest hindrances to citrus culture in Porto Rico.

REPORT OF THE ASSISTANT HORTICULTURIST.

By T. B. McClelland.

COFFEE.

The coffee crop of the past year was the largest since the American occupation of the island, and in American gold its value was the greatest of any Porto Rican coffee crop in the history of the industry. A few such years would bring most decided prosperity to the coffee growers.

The plantings of Porto Rican coffee at the station are not being enlarged, but plantings of promising foreign varieties are being made of sufficient extent to serve as valuable tests. A recent addition, which it is thought may prove of value, is San Ramon coffee from Costa Rica. This coffee is said to thrive in exposed situations and under conditions very unfavorable to the ordinary Arabian coffee. If it lives up to its reputation it will prove a most valuable acquisition. There are several hundred thrifty young plants of this variety now in the nursery beds.

Nearly an acre was planted to *Coffea dewevrei* and plants were distributed to numerous coffee planters over the island for tests. Additional plantings were also made of *C. liberica* and *C. laurentii*. The latter is now being very extensively planted in Java.

The cultural, shading, pruning, liming, and fertilizer tests are being continued. In fertilizer tests in some cases very striking differences have been noted, but before definite results with fertilizers can be obtained more time must elapse and there must be more duplications of the tests to verify results. Stable manure is undoubtedly very beneficial. In one planting the trees which had received an ample allowance of stable manure gave double the yield obtained from the check plats.

A number of coffees which had not hitherto borne blossomed this spring, among them *C. laurentii*, *C. canephora*, *C. stenophylla*, *C. abeokuta*, Leroy coffee sometimes classified as *C. laurina*, and several coffee hybrids and crosses.

The trees of the columnaris coffee are at present loaded with a heavy crop. This variety differed from other coffees at the station in that until it had made a large well-developed tree almost no fruit was produced. If it continues to bear as at present it will likely prove a most valuable coffee for the island.

Many requests for coffee seed were filled in the autumn.

A very good method of handling the guamá ant, *Myrmelachista ambigua* subsp. *ramulorum*, which is so troublesome in coffee, has been found where colonies occur only in isolated guamá trees, as is sometimes the case. Eleven such trees had all of the younger growth and smaller branches removed and burned immediately. The trunks were then banded with tanglefoot. In this way a large part of the ants was destroyed and practically all of the large fleshy pink scale on which they feed. A month later, on some trees no ants whatever were seen, on one the ants were dying and a fungus was seen on them, while on others the tanglefoot had been bridged. Though the ants continued to live for a while on some of the trees, they eventually disappeared from all of those treated.

CACAO.

Beginning January, 1913, a record is being kept of the individual yields of all of the surviving trees of the cacao planting of 1903. These vary extremely, in one picking running from 1 to 26 fruits. As numerous pickings are made throughout the year the individual yields for the whole season show wide differences in the trees in regard to productivity. Through this record it will be possible to make accurate selection of the most valuable trees for propagation. Only about two out of every three trees are producing. Considering only those producing, the yield for the year ending December, 1912, averaged a fraction less than 10 pods per tree, or nearly four-fifths of a pound of marketable cacao. Though mature pods may be found at any time, there is always a very noticeable increase in the late spring and late autumn pickings.

Cacao now brings 14 cents per pound in the local market, which is a considerably better price than formerly.

VANILLA.

The size of the vanillery was very considerably increased and a sufficient number of plants of *Vanilla planifolia* have now been started to serve as a valuable test of its commercial prospects under local conditions. The vines are placed under varying conditions of sun and shade and the needs of the plant in this respect will be studied. Heretofore the prospects for fruit have been largely sacrificed to furnish material for cuttings. From now on the vines will be pruned only when advisable for their welfare and all their energy will be directed toward fruiting. The first crop of pods of *Vanilla planifolia* from plants received from the Subtropical Laboratory at Miami, Fla., in December, 1909, was matured in the fall of 1912. The longest pod was 8½ inches in length.

Vanilla pompona has made a great growth of vine but has failed to blossom this year. *Vanilla* sp., "Pompón," S. P. I. 14540, from

Vera Cruz, Mexico, has blossomed for three seasons. The blossoms were close-pollinated the first two seasons. Fruit set but all fell without maturing. This season some blossoms were close-pollinated while for others pollen was applied from flowers from a different raceme of the same plant. Both lots of blossoms set fruit but all fell without maturing. Some of the Panama vanillas have grown luxuriantly and are bearing well. They are all of the thick-podded type, 6½ inches being the greatest length of pod so far produced.

RUBBER.

Monthly tappings are being made of 38 of the 10 to 11 year old Castilla trees, running from 24½ to 40 inches in girth at 3 feet above base. (Pl. II, fig. 2.) The tapping is done with an inch and a half chisel, there being cut per tree four vertical rows each of seven horizontal cuts. The latex is allowed to coagulate on the tree and on leaves spread at its base to catch the overflow. It is collected the next day as scrap rubber, washed, and pressed into a cake. The rubber collected from the leaves in eight tappings varied in weight approximately from one-fifteenth to four-fifteenths of the whole. For the eight tappings the average yield per tree per tapping was a little less than half an ounce of rubber. A sample was sent to the editor of the India Rubber World, who pronounced it "in quality along with the best and toughest Castilla rubber that the market sees."

COFFEE AND CACAO IN VENEZUELA.

In April a trip was made to Venezuela to study plantation practices in coffee and cacao production and to bring from there plants of economic or ornamental value.

The coffee plantations visited were chiefly on level land affording cultural possibilities that were not taken advantage of. The best were irrigated, and those without water were suffering severely from drought. The spacing of the coffee was slightly wider than that generally practiced in Porto Rico. Near Caracas were seen some coffee trees still productive, said to have been planted about 1778, the first coffee trees in Venezuela. In the coffee plantations a very heterogeneous shade is used, though the preferences are for Ingas for high lands and Erythrinas and *Pithecolobium saman* for low. As *Inga fastuosa* is not known to have been introduced into Porto Rico, though extensively used in Venezuela, seed were obtained of this and of several species of Erythrina, and of all there are now thrifty plants set in the station plantings of coffee and cacao.

Various cacao estates were visited, including those of Chuau, where the finest cacao in the world is said to be grown, selling at 33⅓ to

34½ cents a pound. From these estates an attempt has been made to eliminate as much as possible the trees producing seeds of a dark purple color in section, and to propagate only from those which are white to pale pink or lavender in section, as the latter are much less bitter in flavor. The practice of coating the cacao with earth of a brick-dust color is quite universal. It is claimed that this better preserves the cacao. This process of course adds some weight and makes a product of uniform and pretty appearance.

The cacao trees are spaced at about 12 feet each way. Their branch system is kept quite low, which much facilitates the gathering. The plantations are shaded and irrigation is practiced.

As a windbreak, *Anacardium rhinocarpus*, á wild cashew, which attains gigantic size, is used to some extent. Seed of this and pods of several of the choicer varieties of cacao were brought back. Seeds or plants of valuable hardwood forest trees, promising varieties of vegetables, and of various ornamentals not found in Porto Rico were also secured, and a large collection of orchids was made in a trip through the virgin forest.

REPORT OF THE PLANT PATHOLOGIST.

By G L. Fawcett.

CACAO DISEASES.

The work with cacao diseases was carried so far that some definite conclusions are possible, some of which are included in this report. The work having been interrupted, it seems well to present some of the results without waiting until a more complete report is possible.

Cacao is not an important crop in Porto Rico. It is grown quite generally, however, though evidently less than formerly. There are few coffee plantations without some of these trees. They receive the same care as that given the coffee trees among which they grow, that is, the ground about them is weeded occasionally if the shade is not sufficient to make this unnecessary. That old neglected trees should be diseased is to be expected. But diseases are also very common among the well-cultivated trees belonging to this station where this work was carried on.

The black pod disease of Porto Rico, which is distinct from the disease generally known by that name, is confined to young fruits, principally to those of 12 centimeters or less in length, although larger fruits are sometimes affected. The trees during the fruiting season bear many brown or blackened pods which conspicuously mark its presence. In the case of the green varieties the first symptom is the taking on of a lighter or yellowish color. Later the pods become somewhat flaccid, yellow, and then become brown, the browning beginning at either or both ends, often appearing also very soon in the longitudinal depressions. Then the pod blackens and shrivels, but remains hanging to the tree. Later, various fungi appear on the fruit. In the case of the varieties with red pods the same thing takes place, the preliminary loss of chlorophyll being somewhat concealed by the red coloring matter.

The loss apparently is great, as on many trees not more than 5 per cent of the fruits that set reach maturity. It is to be noticed that although all the fruits of young or weak trees blacken, the larger and older trees always bear some good pods. The pods that develop are generally situated on the trunk and larger limbs. It is also to be observed that if more than one fruit is borne on a cushion, although all may become several centimeters long, they die off gradually, beginning with the smallest until but one or, rarely, two are left. The symptoms are always the same whether the fruit is one of the small ones near the end of the branch or in the cushions of larger fruit on the trunk. This behavior of the disease, with reference to the situation of the fruits and their proximity to other fruits, suggests that food supply is the controlling factor in determining whether they mature.

To find what relation, if any, might exist between fungi and bacteria and this failure of the pods to mature, numerous cultures were made with material from the interior tissues, this being selected from various parts of the fruits. From fruits showing the first symptoms of the disease no organisms were obtained, their interior tissues being found to be free from both bacteria and fungi. This was also found to be true of many fruits that had become quite brown. Occasionally a Glœosporium developed in cultures from these, and the same fungus was obtained frequently from the more advanced stages. This Glœosporium in cultures appears identical with that obtained from cultures from the spores of a Colletotrichum which produces an anthracnose of the pods, which is characterized in its earlier stages by sunken brown spots on the pod and which is occasionally to be found, though it is not common. This fungus agrees fairly well with the description of *C. cradwickii.* In sterile culture chambers after being sterilized externally by moistening with alcohol and placing in 4 per cent formalin for 30 minutes and then washed in sterilized water, Glœosporium developed in about one-third of the fruits with blackening tips, and not in those that were merely yellow. With less thorough disinfection Fusarium of two types and occasionally *Nectria bainii* developed on some of the fruits.

To test the parasitism of these fungi by inoculation into fruits on the tree and of the same size and age as the ones commonly diseased is difficult, for the reason that all the check fruits invariably succumbed, as well as all those into which inoculations were made, without regard to the nature of organism used. All the species isolated were inoculated into larger healthy fruits which gave promise by their size and color of being able to mature. On these fruits the inoculation with all the fungi failed to take except those with the Colletotrichum, which, when spores were introduced into small wounds made with a scalpel and covered with adhesive tape, sometimes resulted in the formation of small black spots from which the fungus could be reisolated. When merely applied to the surface or into very small wounds made with a needle, no spots were formed.

An attempt was made to increase the number of fruits maturing by spraying the trees with Bordeaux mixture. The spraying, although repeated frequently, had no effect, the sprayed trees yielding no more pods than the unsprayed. The spraying was carried on for two seasons. A further test of the effect of fungicides was made by applying the spray by means of a hand sprayer to certain fruits from the time they had reached a few millimeters in length so frequently that they were always protected by a coating of the spray. In addition to Bordeaux a one-half per cent solution of carbolineum and a similar dilution of iron chlorid were used, the latter to see if it would correct the tendency to loss of chlorophyll in the fruits as it is known to do in chlorotic leaves, but this treatment also failed to show beneficial effects.

The work up to this point would indicate that the trouble is not due to parasitic fungi, this being indicated by the freedom of the fruits from fungi in the earliest stages and the fact that the commonly present Colletotrichum is but weakly parasitic. The result of the sprayings confirms this idea. It would seem that this so-called disease is caused, at least in part, by the trees setting more fruit than they are capable of supplying with food materials, the result being that the weaker and younger fruits die. A similar phenomenon is occasionally to be seen in grapefruit groves, only in the latter case the fruits fall and the effect is not so noticeable. The superfluous cacao fruits do not fall, but adhere for some weeks, become black, and give the tree a rather alarming appearance, suggesting the ravages of disease.

Those of the diseased fruit which happen to be infected with the Colletotrichum could possibly be regarded as affected with the "Jamaica pod disease" (*C. cradwickii*), in which case that fungus is clearly not a dangerous parasite. In its attacking young fruits and in the blackening resulting therefrom, the black rot disease of Trinidad and other West Indian islands most closely resembles this Porto Rican cacao disease. That such a resemblance exists, at least in its later stages, is also affirmed by persons familiar with both the Porto Rican disease and the black rot. This would suggest that all the injury ascribed to the undoubtedly parasitic fungus of the black rot is not necessarily caused by that fungus. If conditions elsewhere resemble those of this island, many of the fruits would be lost without the action of any fungus. *Phytophthora faberi* has not been found in Porto Rico.

The effect of fertilizers on the trees, with regard to lessening the number of fruits that fail to mature, is being tried in cooperation with the assistant horticulturist. It seems probable that although such fertilizing may increase the vigor of the trees, and thus the yield of good pods, the ratio of the number of such pods to the number of those remaining undeveloped can not be materially changed.

Early in the work some attention was paid to the insects, aphids and mealy bugs with ants being very common. Protection from these insects by means of wire cloth and by using insecticides was without beneficial effect, as many fruits dying on the protected as on the unprotected trees. Any injurious effect from these insects must be very small. In any event, it has nothing to do with the failure of the fruits to develop.

CITRUS DISEASES.

In the work with these diseases an interesting result was obtained with regard to the lemon scab. The fungus producing this disease attacks the grapefruit when quite small, producing wart-like outgrowths which greatly disfigure the full-grown fruit, causing it to sell at a lower figure. The disease is very common, so that it often seems merely a question of a suitable host as to whether or not it makes its appearance in the grove. Such general distribution would indicate the possibility of its having other hosts than the citrus trees or that other fungi than the Cladosporium usually found on the lemon cause the trouble.

What are apparently other species of this fungus are common on the wild plants found in many of the groves as well as on the legumes grown as cover crops. The gandul, a legume often grown as a temporary windbreak for young plants, was so often found near the worst diseased plants as to suggest that a Cladosporium causing spots on its leaves could have something to do with the trouble. Inoculations made with this fungus on young grapefruit produced warty outgrowths, and young lemon plants similarly inoculated have developed scab identical in appearance with that produced on lemon leaves by *C. citri.* The Cladosporium of the gandul differs somewhat in appearance from that of the lemon, but they may later be shown to be identical. Inoculations with species of Cladosporium of other plants are being made. It seems clear that the scab of grapefruit may, in many instances, be due to infection from the gandul. Should it be shown that scab-producing fungi are quite common on other plants, the importance of clean cultivation in avoiding this disease would be evident.

COFFEE.

The diseases which cause the coffee grain to be classed of lower quality and make its preparation more difficult have been studied. Of these, the one caused by *Cercospora coffeicola* seems to be the most harmful. This fungus has hitherto been considered a leaf parasite of small importance. The injury resulting from its attacks consists, in part, in causing the grain to be more difficult to prepare. It also causes the grain to become black and shriveled. The effect of the disease in shaded and unshaded trees has been studied, and the relative proportion of bad grains in coffee from trees under various conditions has been established by determining the proportion of such grains in numerous samples. The injurious effect of sunlight on the trees has been generally recognized, but it would seem that its effect on the quality of the grain, through its producing conditions favoring the development of this fungus, is equally bad.

REPORT OF THE ANIMAL HUSBANDMAN.

By E. G. Ritzman.

The fact that weather and soil conditions in the neighborhood of Mayaguez are very unfavorable for stock raising has necessarily forced the station to carry on more of its work of breeding in cooperation with stock growers more favorably located in this respect. This policy has, however, been compensated by the greater interest stimulated through such direct contact. The chief lines of cooperation in the past included work with horses and cattle, mentioned in previous reports, and African woolless sheep. During the year similar experiments were begun with the more promising introductions of the grasses obtained from the Bureau of Plant Industry and more especially with alfalfa. The chief object sought in this work is to obtain suitable legumes for forage as well as good drought-resisting grasses.

HORSE BREEDING.

The station had only three horses during the year. The saddle-bred horse, Black Badger, which was brought down last year, was placed in a stud near Coamo. The Morgan colt, Edmunds, made a fair development at the station. He is now going on 3 years and will be used lightly for stud work next year.

The oldest colts sired by horses formerly owned by the station are now going on 3 years and by next year will give some definite idea as to their ultimate value for carriage use. Comments made in the last report on these colts seem so far fully substantiated, and further report will be made next year when they are broken and more nearly mature.

CATTLE BREEDING.

The chief line of work with cattle during the past four years has been with Zebu blood on native cattle. The primary object has been to increase the working efficiency of the draft ox. The bulls used in this experiment were obtained by crossing pure-bred Zebu sires of one of the largest and most improved breeds of India on Shorthorn and Hereford cows. These bulls, now fully developed, are magnificent specimens. (Pl. III, fig. 1.) They stand about 68 inches at the hump. The Shorthorn and Hereford blood has broadened the frame somewhat and given more depth of body than is usual in the pure-bred Zebu. It has also given a tendency toward earlier maturity. These factors are an asset as a beef proposition. Fortunately the chief factors for tropical consideration which are characteristic of the pure Zebu have been fully retained. Those characteristics consist of exceptional constitutional vigor, active movement, strong bone, straight legs, hard hoofs, and a straight, easy, and rapid gait. Equally important Zebu characteristics, however, are almost complete immunity to tick infestation, together with natural adaptation to tropical heat and short pasturage.

The progeny of these bulls from Porto Rican cows now number over 300 head, of which some are just 2 years old, some yearlings, and some suckling calves, about equally divided in number. (Pl. III, fig. 2.) The consensus of opinion among breeders who bred them and who have been engaged in breeding native stock for years is the best criterion of their value compared with native stock. This opinion, which refers only to growing stock, is summed up as follows: The newborn calves are larger and stronger; yearlings and 2-year olds are larger and keep in better flesh on short pastures; they carry practically no ticks, which undoubtedly permits them to keep in better flesh as they loose less blood; they keep in excellent health, are vigorous and thrifty, and show strong indications of some advance toward earlier maturity.

They possess the general essentials already described in their sires. There is apparently a relation between the black skin with light-colored short hair and the Zebus' adaptability to tropical conditions. In support of this Wallace's observations "that cattle having only a fraction of Zebu blood never stand in water to get relief from heat" are borne out here, which certainly is in marked contrast to the habits of American and European breeds. The shortness of coat, which leaves even small seed ticks almost entirely exposed, is undoubtedly a strong factor in keeping them free of ticks, and it is to this that successful stockmen here pay a great deal of attention. Jerseys and other breeds, which also have short hair, carry fewer ticks than those with long hair, but they are much more subject to infestation than cattle with even a small fraction of Zebu blood, which suggests that the Zebu skin has some repellence to the parasite.

The dairy herd at the station now consists of five crossbred Shorthorn native cows, one pure-bred Jersey, and two pure-bred natives. In addition to this there are two heifer calves which are three-quarters Shorthorn and one-quarter native. The Jersey has kept in good health and, though subject to tick infestation, has done well as a milker. Of the natives, one is a fair milker and one very inferior. The Shorthorns, four of which are now in milk, give small promise of dairy improvement, but are undoubtedly superior for beef. The half-breds are not troubled with ticks seriously, as their coats are comparatively short. The three-quarter breds have the long woolly coat of the Shorthorns, and are almost as subject to tick infestation as pure breds. These are very important considerations here, and show that in combining improved foreign blood for dairy improvement the purely tropical characteristics should not be lost, as the lack of natural adaptation will prevent even high-yielding cows from attaining maximum efficiency.

SHEEP.

Sheep-breeding operations were abandoned at the station owing to the difficulty experienced in keeping the animals in good health in this locality. Over half the lambs dropped were lost annually from the effect of flukes, which are a constant menace during the rainy season. Of the African woolless sheep mentioned in previous reports of the station, a few flocks have been started on the south side of the island. The largest of these was begun with a male and two females sent by this station three years ago to test their adaptability under more suitable soil and weather conditions. This flock now numbers 60 head, 40 more have been slaughtered or sold, and none have been lost by disease. While wool sheep here have been affected with scab, none has ever been seen on the African sheep although they grazed with the affected sheep. The African sheep breed at any season here after one year of age, and almost without exception drop twins. This flock, which pastures on limestone soil, has kept in splendid health and flesh during all seasons of the year.[1] They carry a good leg of mutton and are fairly well fleshed over the back. The flavor and quality of their meat is not excelled by any of the mutton breeds. They are naturally adapted to this latitude and need improvement only by adding some additional flesh. They are essentially a tropical breed, even more so than the Tunis sheep.[2] Their advantages for a hot tropical climate is a black skin which permits of rapid radiation of excess body heat, and a yellowish brown coat of hair which is a good reflector of heat and light rays. While improvement for better mutton form by selection would be slow, yet it would no doubt be safer than by crossing, as the introduction of new characters by a Temperate Zone breed would also probably tend to lessen their adaptability to tropical conditions. The standard of health which they now maintain enables them to keep in better flesh than breeds not so well adapted, and their extreme fecundity, together with a natural instinct to browse, gives a valuable animal for the utilization of lands not suitable for cattle but otherwise favorably located.

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[1] The writer has seen these same sheep as far north as Washington, but though they seemed to keep in excellent health there they did not carry as much flesh as they do on the south side of Porto Rico, probably because they were out of their natural habitat.

[2] Tunis sheep, which are wooled, are often regarded as a tropical breed, an erroneous impression, as Tunis, though a mild and well tempered country as regards climate, is above latitude 30° or well within that of the Southern States, not including the peninsula of Florida.

PLATE III.

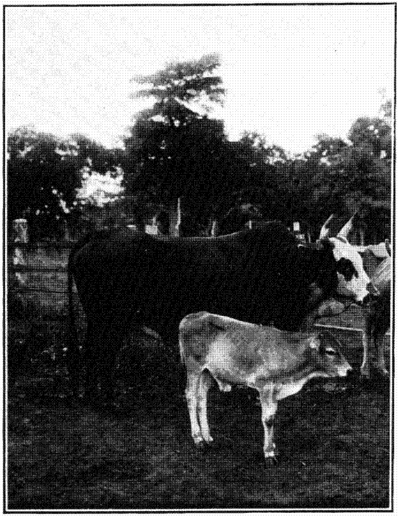

FIG. 1.—HALF-BRED ZEBU BULL AND CALF.

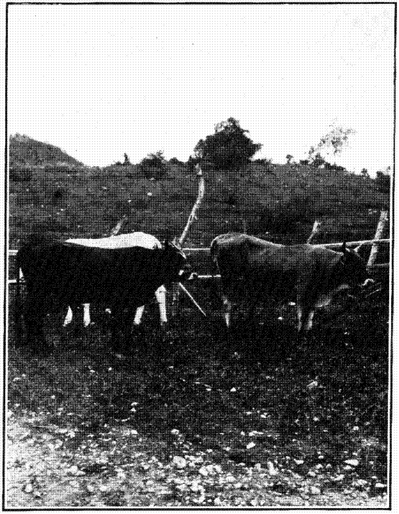

FIG. 2.—CROSSBRED CATTLE—HALF-BRED ZEBU AND NATIVE COWS.

FORAGE CROPS.

In addition to those forage crops mentioned in the last report some additional varieties, principally grasses, were obtained from the Bureau of Plant Industry of the United States Department of Agriculture. Part of the seed was planted in field plats and part in seed boxes, where better control could be kept.

Tricholæna rosea promises to be very productive, as it grows quickly and forms a dense stool. The varieties of Kerstingiella are slow growers and produce very little forage here. Their growth at Mayaguez is so inferior as to promise little either for forage or soil renovation.

A beginning has been made toward the improvement of the native corn. About an acre has been planted and harvested. Half of this area was planted from selected kernels and the other half from unselected for comparison. The difference in germination was 8 per cent in favor of the selected seed. There was also a difference in appearance and yield in favor of the selected seed. Selected seed produced nearly 12 per cent more corn and 6 per cent more fodder. Corn is now one of the chief fodder crops in Porto Rico. The native variety is so inferior in shape of ear and grain that with systematic selection the yield should be doubled.

Efforts to grow alfafa have been begun in cooperation with planters on the south side of the island, which is the section probably best adapted to its growth. The station furnished the seed and supervised planting. Six plats, ranging from $\frac{1}{10}$ acre to 2 acres, have so far been seeded. Incidentally small seed plats of the various grasses were also established with each alfalfa plat.

MISCELLANEOUS.

The development of the poultry industry in Porto Rico is still somewhat hampered by the high price of feeds, practically all of which is now imported ready mixed. The price of scratch feeds has been approximately $2.75 per hundred pounds and of mash feeds about the same, the cost varying in different localities. Samples of scratch feed have been obtained from poultry feed manufacturers in the States and examined as to their ingredients. Four representative scratch feeds were composed of corn, wheat, oats, sorghum or Kafir corn, barley, buckwheat, bone, sunflower seed, charcoal, and weed seed.

Seventy-five per cent of the ingredients in some of these feeds can be easily grown or produced in Porto Rico. This includes corn, sorghum, sunflower seed, charcoal, and bone. Oats can be purchased for less than $2 per hundred pounds, while buckwheat and barley can be omitted without a lack of variety in the mixture. This leaves only wheat as a necessary part of the mixture which is not available here. A greater utilization of locally grown products would no doubt effect a reduction in the price of poultry feeds. It has also been the practice at the station to prepare poultry mashes. While all the ingredients are imported products, yet some saving has been made by buying them separate and making the mixture. The standard mixtures used cost about $2.35 per hundredweight and are made up as follows:

Rations used for poultry at station.

Ingredients.	Ration No. 1.	Ration No. 2.
	Pounds.	*Pounds.*
Corn meal	200	100
Wheat shorts	200	100
Bran or wheat middlings	200	200
Beef scraps	100	75
Total	700	475
Nutritive ratio	1:3.2	1:2.9

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